Test Report: A Telescope for Beginners

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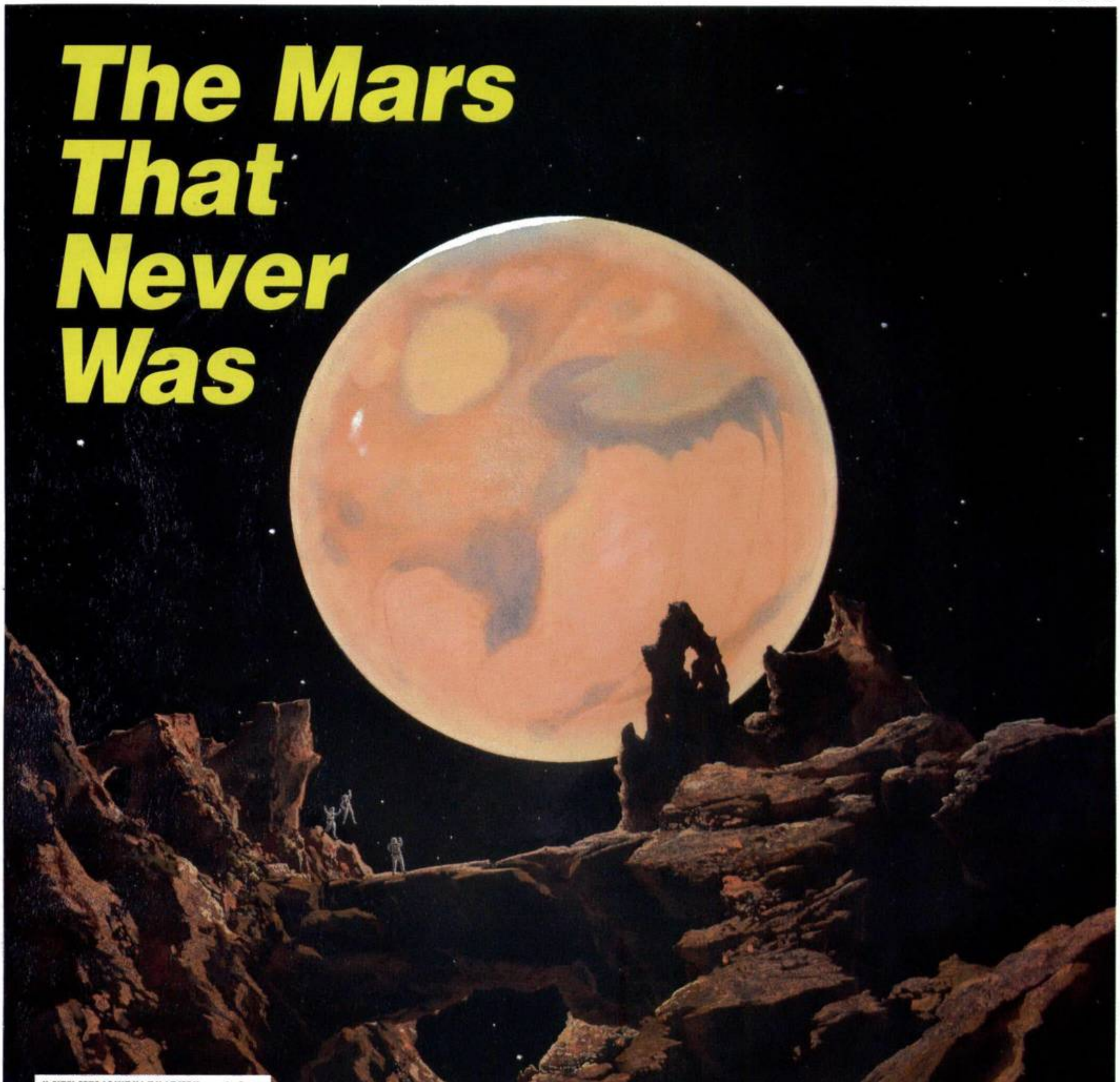
The Mars That Never Was



Viewing the Secrets of the Orion Nebula

In Your Face: Seeing Spiral Galaxies

12"
MEADE LX200 EMC
10"
MEADE LX200 EMC
7"
MEADE LX200 EMC
8"
MEADE LX200 EMC
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MEADE LX200

MEA

LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models ***combined***. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of over 64,350 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
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- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an auto cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); complete operating instructions.

8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**2895.**
12" LX200 Schmidt-Cassegrain	**3995.**
7" LX200 Maksutov-Cassegrain	**2995.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

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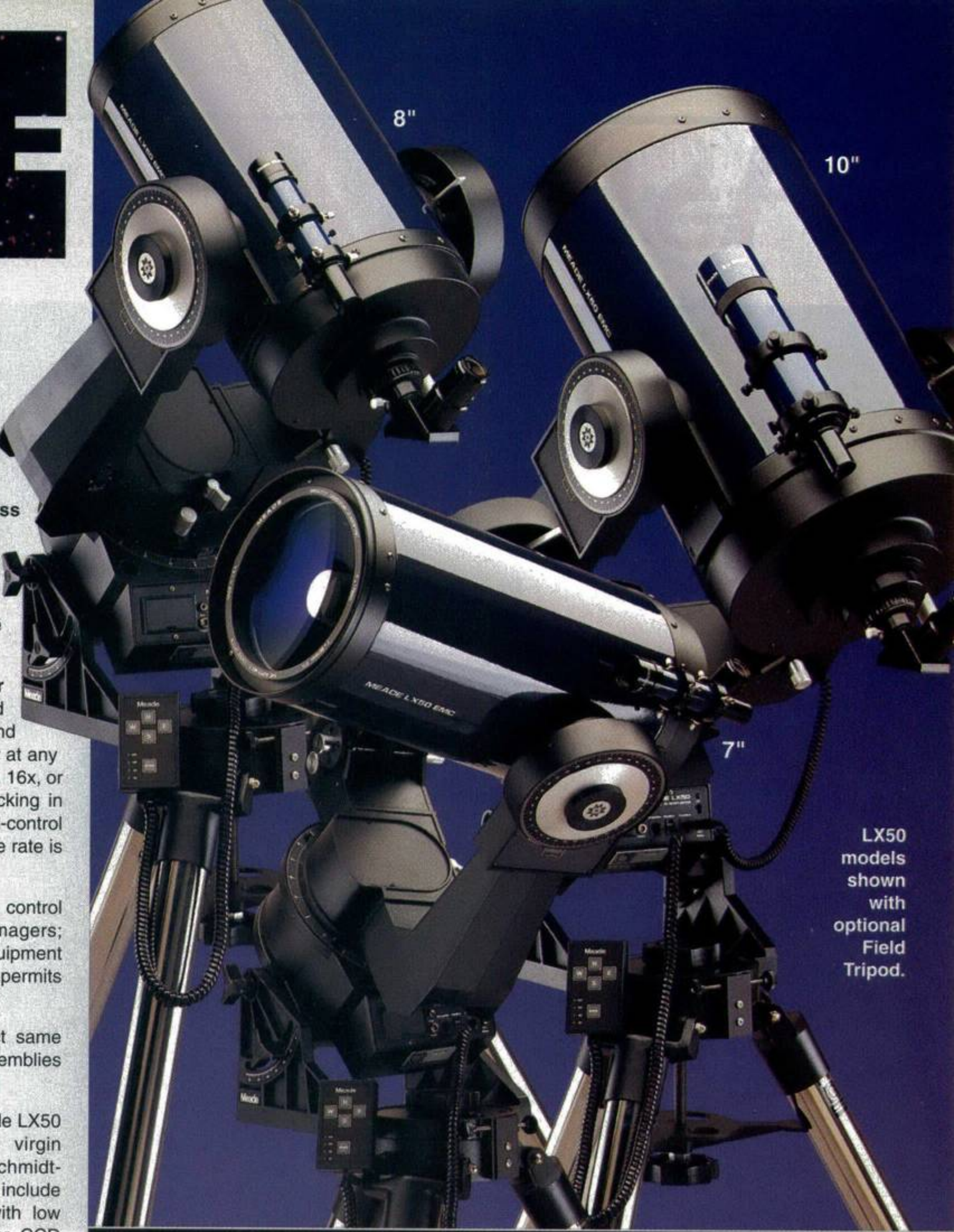
Advanced technology at the most affordable prices ever.



LX50 models shown with optional Field Tripod.

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from four AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

- **Multi-Function Control Panel:** Includes control panel connectors for CCD autoguider/imagers; electric focuser; and for the standard-equipment Declination motor. A North-South switch permits telescope operation anywhere in the world.

- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting four (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1195.**
10" LX50 Schmidt-Cassegrain	**1495.**
7" LX50 Maksutov-Cassegrain	**1595.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y, only	**1195.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), completely concealed in special LX50 encoder compartments. ■ Quick 2-star alignment. ■ Large 32-character, red-backlighted display. ■ 4-speed (2x, 8x, 16x, 32x sidereal) dual-axis, drive corrector/microslewing system.

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World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur

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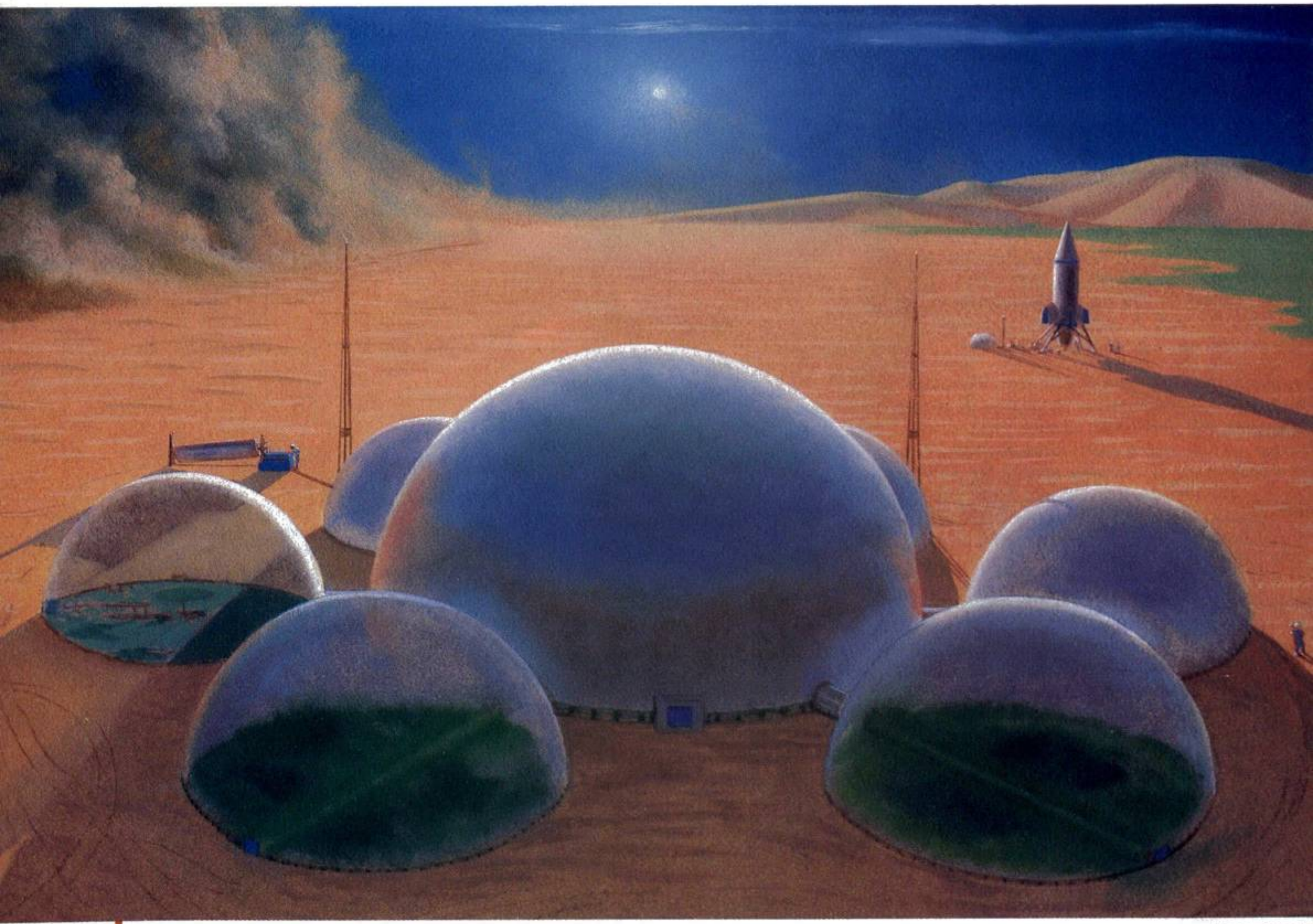
Vol. 23, No. 12



Chesley Bonestell

36 The Mars That Never Was

ON THE COVER

IT'S NOT THE MARS WE KNOW from Mariner and Viking, but the Mars envisioned by astronomers in the 1950s. Come explore this vibrant world through the eyes of renowned space artist Chesley Bonestell, beginning on page 36. Painting by Chesley Bonestell.

COVER 36 **The Mars That Never Was**
Forty years ago, space artist Chesley Bonestell fired an entire generation's imagination with visions of Martian canals, wetlands, and possible primitive life.
By Edmund A. Fortier.

46 **Epsilon Eridani: The Once & Future Sun**
This young, nearby star bears a close resemblance to the Sun in its early days, and may one day nurture intelligent life. By Ken Croswell.

52 **Our Strange, Scrappy Ancestors**
Hubble reveals a new class of very distant, fragmentary galaxies that may be the most abundant kind in the universe. By David J. Eicher.

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Debate rages over whether these powerful explosions originate in the outskirts of our galaxy, or far across the universe. By Richard Talcott.

Jason Ware

78 Viewing the Secrets of the Orion Nebula

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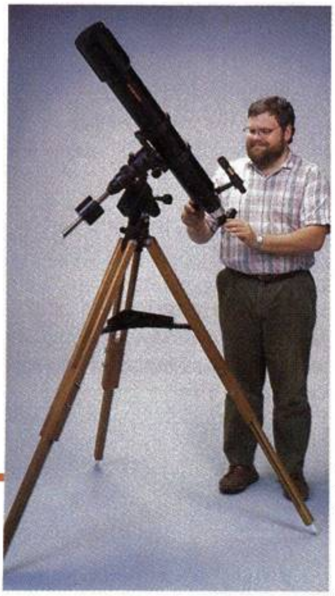
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Geminid meteors will be shooting across mid-December's evening sky, a fitting encore after watching six planets low in the western twilight. By Deborah Byrd and Rick Shaffer.

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This redesigned 4-inch apochromat features superb optics on a sturdy German equatorial mount. By John Shibley.

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A medium-size scope reveals stunning detail in winter's showpiece deep-sky object, but the right filters will help you see new shapes and boundaries. By Alister Ling.

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The right books can help you get the most out of your astronomy pursuits. By Mark J. Coco.

88 When Galaxies Strut Their Stuff
Face-on spiral galaxies offer observers with small scopes their best look at mottled arms, pointlike nuclei, and star-forming regions. By David J. Eicher.

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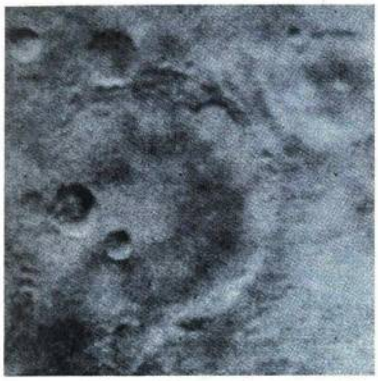
BEHIND THE SCENES

The Mars That Never Was

Percival Lowell's vision of an Earth-like Mars was a glorious dream, but it died with a thud in the summer of 1965. Anyone who remembers the arrival of Mariner 4's handful of images that long ago July also remembers the sharp disappointment they caused. "It looks like the Moon!" I thought glumly, and the solar system felt colder and lonelier. I don't know exactly what I *had* expected to see, but it sure didn't include craterscapes like frame #11, the photo most widely reproduced.

Yet if Lowell's Mars was a false vision, it had nonetheless energized generations of planetary astronomers, not to mention millions of ordinary humans. One of those caught up in the dream was Wernher von Braun. In 1953 — before NASA even existed — he wrote a book showing how people could go to Mars. Von Braun's daring and imaginative plan was publicized by *Collier's* magazine, which commissioned space artist Chesley Bonestell to paint scenes of a manned Mars expedition based on von Braun's ideas.

NASA/JPL



The Mars that really was: frame 11.

When science writer Ed Fortier approached us about doing a story on the "old Mars" using Bonestell's paintings, I hesitated. That's history, I thought. Who'd care about those old, *wrong* ideas anyway? Yet when I saw the images, I knew we had to do the story that starts on page 36.

The same Mariner 4 mission that burst the bubble of Lowell's Mars also kickstarted the modern science of the Red Planet. By an exquisite irony, the outcome is a new view of Mars that goes a surprising way back toward what Lowell envisioned. Of course, no one is proposing that intelligent Martians existed, much less built planet-wide water projects. But many elements of the old Mars can be found in the Mars of today. This is a planet that once saw running water and perhaps even oceans, plus enormous volcanic eruptions. It's a Mars of climate change and dynamic weather that Lowell would have recognized.

Post-Mariner and post-Viking, I look at Bonestell's paintings with an eye less critical and more appreciative. I'm impressed more by the things he got right than details (like blue skies) that are wrong. And there's a spirit of adventure he painted that we could sure use today.

As NASA readies Mars Pathfinder, our next mission to the Red Planet (scheduled for launch in November '96), the "Mars that never was" makes an excellent prologue to the Mars that is and will be.

Sincerely,

Robert Burnham
Editor
rburnham@astronomy.com

LETTERS

Astronomy Clubs Do Help

I'm sorry that Bob Cook feels astronomy clubs are composed of a bunch of "old guys" and that they are detrimental to the advancement of amateur astronomy (Letters, June 1995). Before I joined the San Diego Astronomy Association, I saw things in pretty much the same way. I joined, hoping things would be different, and they were. I am now president of the SDAA and quite proud of our efforts to bring astronomy to the public and foster interest in the young.

The SDAA holds regular monthly star parties in San Diego's Balboa Park. Attendance often exceeds 300. Members set up their telescopes for public viewing and never charge for peeks at celestial wonders. We answer every query, and treat none as a "dumb question." Our dark sky site, 70 miles east of San Diego, is open twice a month for anyone who wants to use it.

Is the SDAA unusual? I think not. I talk with members of clubs from across the country and most are involved in astronomy education and public awareness. So Bob, if you run into that one-in-a-million grumpy troll of an astronomer, walk right past him and on to the rest of us. — *Brian V. Staples, San Diego, California, bstaples@digcir.cts.com*

A Few Decades to Catch Up, Please. . .

Like many others, I found C. Renée Beveridge's "Standing on the Shoulders of Giants" (September 1995) quite amusing. But you don't have to go back to 1902 to find references to "The Andromeda Nebula." The first field book I owned was the fourth edition of the *Field Book of the Skies* by Olcott and Mayall (G.P. Putnam's Sons, New York, 1954). On page 266 there's a six-paragraph discussion of the "nebula," and M51 is likewise dubbed a "spiral nebula."

Despite this, I find the book helpful when planning observing sessions.

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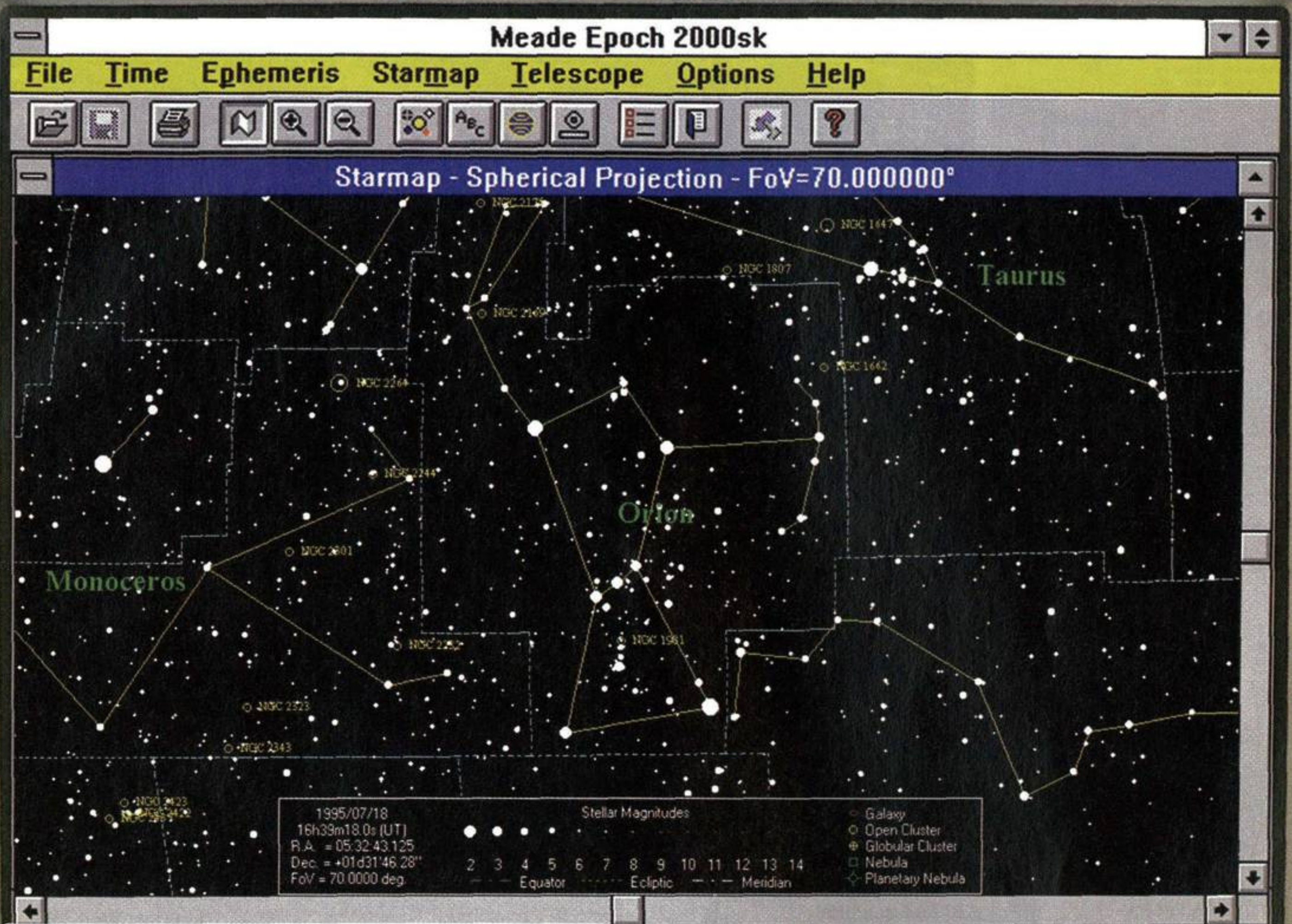
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Galaxy
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Globular Cluster
Nebula
Planetary Nebula

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Epoch 2000sk *(above)* displays stars, planets, asteroids, and comets accurate in position to an *arc-second* level, the most precise position display of any sky software yet developed.

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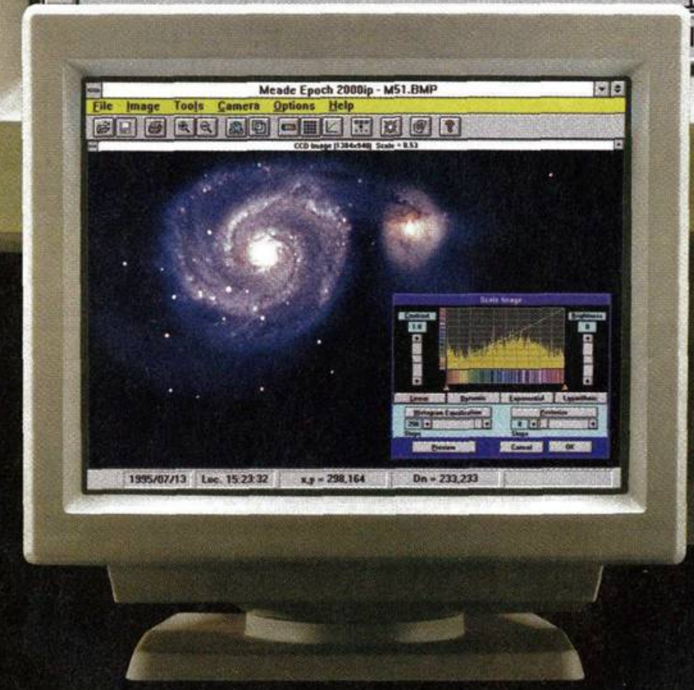
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#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm. **$79.95** (3.29)

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Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

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6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$87.95** (3.45)
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56mm (52°; 2")		**229.95** (5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (3.60)

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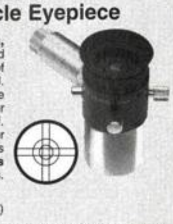

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25" **$149.95** (3.45)

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Series 4000™ Super Wide Angle 67°

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The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

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Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (2.98)

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For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera. **$39.95** (2.98)

Variable-Projection Camera Adapter (1.25")

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T-Adapters for SCT's

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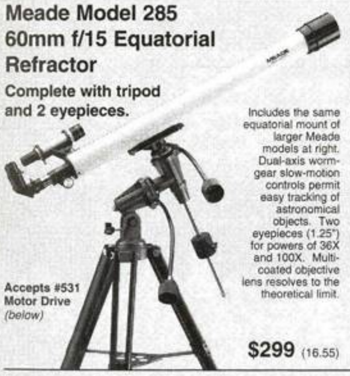
Meade Model 285 60mm f/15 Equatorial Refractor

Complete with tripod and 2 eyepieces.



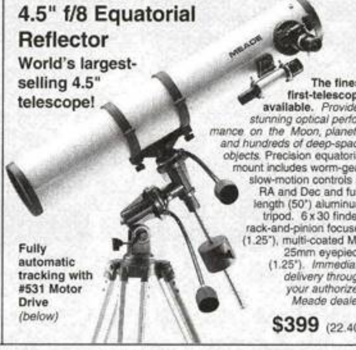
Includes the same equatorial mount of larger Meade models at right. Dual-axis worm-gear slow-motion controls permit easy tracking of astronomical objects. Two eyepieces (1.25") for powers of 36X and 100X. Multi-coated objective lens resolves to the theoretical limit.

Accepts #531 Motor Drive *(below)*

$299 (16.55)

Meade Model 4500 4.5" f/8 Equatorial Reflector

World's largest-selling 4.5" telescope!



The finest first-telescope available. *Provides stunning optical performance on the Moon, planets, and hundreds of deep-space objects.* Precision equatorial mount includes worm-gear slow-motion controls in RA and Dec and full-length (50") aluminum tripod. 6 x 30 finder, rack-and-pinion focuser (1.25"), multi-coated MA 25mm eyepiece (1.25"). *Immediate delivery through your authorized Meade dealer.*

Fully automatic tracking with #531 Motor Drive *(below)*

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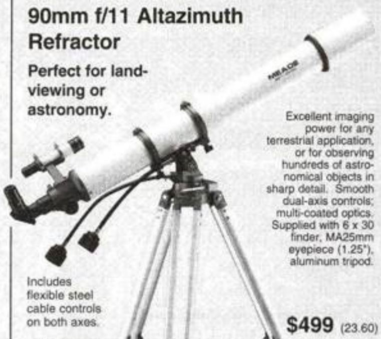


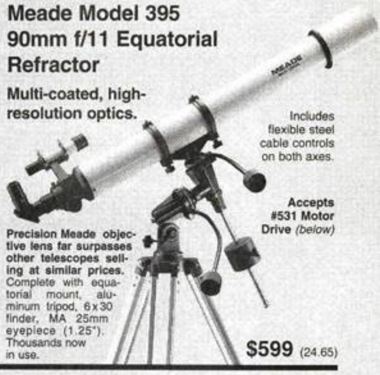
Excellent imaging power for any terrestrial application, or for observing hundreds of astronomical objects in sharp detail. Smooth dual-axis controls; multi-coated optics. Supplied with 6 x 30 finder, MA25mm eyepiece (1.25"), aluminum tripod.

Includes flexible steel cable controls on both axes.

$499 (23.60)

Meade Model 395 90mm f/11 Equatorial Refractor

Multi-coated, high-resolution optics.



Includes flexible steel cable controls on both axes.

Accepts #531 Motor Drive *(below)*

Precision Meade objective lens far surpasses other telescopes selling at similar prices. Complete with equatorial mount, aluminum tripod, 6 x 30 finder, MA 25mm eyepiece (1.25"). Thousands now in use.

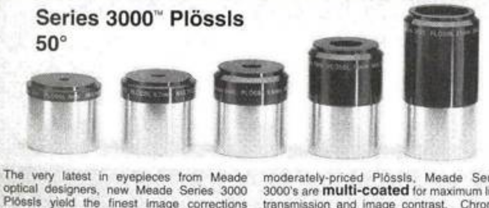
$599 (24.65)

Meade intermediate-size telescopes are the world's largest-selling quality telescopes of their apertures. *They are the only telescopes in this price range designed by Meade engineers and manufactured to exclusive Meade specifications.* Each instrument includes mechanical components, gear systems, and accessories specifically intended for serious applications of the beginning to intermediate amateur astronomer. American-size 1.25" barrel-diameter eyepieces, threaded for filters, are included with all models. Large cable controls facilitate the tracking of astronomical or terrestrial objects, and, on equatorial models, the optional Meade #531 Motor Drive *(see right)* enables fully automatic tracking of astronomical objects.

#531 Motor Drive

Attaches in seconds to the equatorial mounts of Meade Models 285, 4500 or 395 telescopes. Permits fully automatic tracking of celestial objects. Cordless operation anywhere in the world from 3 (user-supplied) AA batteries. **$99.50** (4.78)

Series 3000™ Plössls 50°



The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

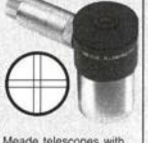
Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

Series 3000™ Plössl 40mm 44°

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°. **$79.95** (3.79)

MA12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.** each: **$37.95** (2.98)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25". **$59.95** (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, at right. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated. **$47.95** (3.45)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25" **$47.95** (3.45)

HOW TO ORDER

- Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.
- Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.
- Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders & Information: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Info/IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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FREE! $800 CCD Equipment System!

Now, for a limited time, when you purchase a Meade Pictor 416 or 1616 CCD imager at the regular price, **we'll include an $800 Meade CCD Equipment System—everything you need for advanced CCD imaging—absolutely FREE!** Purchased separately, the CCD Equipment System is priced at $807 and includes these important products:

Meade Pictor 201 Autoguider: Allows completely automatic guiding of your Pictor camera during CCD imaging or your 35mm camera during long-exposure astrophotography.	**$395.**
Meade CCD Off-Axis Guider System: Complete with adapters for 1.25" eyepiece holders and for Schmidt-Cassegrain rear-cell threads. Use with the Pictor 201 on guide stars to 10th-magnitude.	**119.**
Meade CCD Image-Orientation Adapter: Threads into the Off-Axis Guider and permits precise image orientation on the CCD chip.	**35.**
Meade Epoch 2000ip Image Processing Software: Professional Windows-based image processing that permits the enhancement and analysis of CCD images using the most advanced techniques, including dynamic scaling, histogram equalization, image convolution, unsharp masking, median filtering, RGB merging, and more.	**199.**
Meade Foam-Lined Carrying Case (19" x 14" x 7"): Provides for secure storage and transport of your Pictor 416 or 1616 CCD imager as well as all items of the CCD Equipment System described above.	**59.**
Total price of all items if purchased separately:	**$807.**

The Meade Pictor 416 CCD Imaging Camera is packed, at no additional charge, with the **Meade $800 CCD Equipment System** during the period of this special offer.

EPOCH 2000
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The Trifid Nebula (M20): Pictor 1616; a 5-minute exposure by Jack Newton with the Meade 7" f/9 *ED* Apochromatic Refractor.

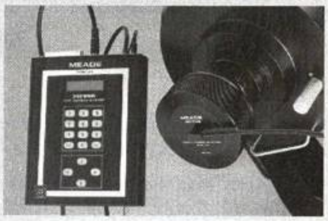
Pictor 201 Autoguider: For flawless, ultraprecise autoguiding during long-exposure astrophotography or CCD imaging. Automatically locks on to guide stars as faint as 10th-magnitude and makes all required dual-axis corrections. Results in perfectly guided astrophotographs or CCD images during even the longest of exposures. Completely self-contained; no host PC required. **$395.** + $10 packing & shipping in 48 states.

Pictor 208 Autoguider/Imager: For an amazingly low price, the 208 gives impressive imaging capability even to the novice. On telescopes of 4" aperture and larger, the Pictor 208 yields very satisfying results and, in addition, is a full-capability autoguider, containing the exact same autoguider hardware and software as the Pictor 201, above. The 208 incorporates the Texas Instruments TC-255 microchip, by far the largest, highest-resolution chip available in any CCD unit in its price range. **$795.** + $15 P & S

Pictor 216 CCD Autoguider/Imager: Identical in operation and size to the 208, the Pictor 216 includes a 16-bit A/D converter for 65,536 brightness levels. The result is a level of image quality only obtainable on competing units that sell for almost twice the 216's price. Combining high-resolution imaging with low dark current, the Pictor 216 satisfies the long-term CCD imaging requirements of the majority of serious amateurs. **$1295.** + $15 P & S

Pictor 416 CCD Autoguider/Imager: Armed with the powerful Kodak KAF-0400 CCD microchip, the Pictor 416 is the most advanced high-resolution CCD system available under $5000. And, with its standard-equipment SCSI interface, the 416 can full-frame download in *one second!* The Pictor 416 is a powerful CCD system on any telescope; attached to a Meade LX200, its capabilities are truly awesome. The auto-mosaic feature, for example, permits the imaging of an arbitrarily large sky area **automatically** on user command. **$2495.** + $25 P & S

Pictor 1616 Autoguider/Imager: For professional-level applications the Pictor 1616 utilizes the Kodak KAF-1600 microchip, one of the largest (13.80 x 9.20mm) CCD chips in commercial production. Identical in pixel density and dark current to the 416, but with *four times* the chip area, the 1616 permits the imaging of very large sky areas: a sky area of 23' x 15' with an 8" f/10 Schmidt-Cassegrain, almost one-half the lunar surface in a single exposure. The 1616 is the finest CCD imaging system available at under-$10,000. **$6495.** + $40 P & S



The special Meade CCD Equipment System offer is effective beginning July 20, 1995, at participating Meade dealers in the U.S.A. and Canada. *This offer is valid until further notice and may be withdrawn at any time.* ■ All prices shown are suggested U.S. national mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable. ■ For safety reasons AC-powered personal computers should be used indoors only. ■ The Meade brochure ***CCD Imaging Made Simple*** is available free of charge, or send $3.00 for the 76-page **Meade *1995 General Catalog.***

AUTHORIZED U.S. MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK, Orders: 800-422-7876; Information: 405-364-0858

CALIFORNIA TELESCOPE COMPANY, Burbank, CA
Orders & Information: 818-505-8424

CITY CAMERA, Dearborn, MI, Orders: 800-359-5085; Information: 313-846-3922

FOCUS CAMERA, Brooklyn, NY, Orders: 800-221-0828; Information: 718-436-6262

LUMICON, Livermore, CA, Orders: 800-767-9576; Information: 510-447-9570

SHUTAN CAMERA & VIDEO, Chicago, IL, Orders: 800-621-2248;
Illinois & Information: 312-332-2000

Canada:

EFSTONSCIENCE, Toronto, Ontario, Orders & Information: 416-787-4581

KHAN SCOPE CENTRE, Toronto, Ontario, Orders & Information: 416-783-4140

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MEADE
STARFINDER DOBSONIANS
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Dobsonian telescopes with quality Meade® optics and components — at a fraction of the price you'd expect to pay.

16" f/4.5
$1095.

12" f/4.8
$795.

10" f/4.5
$595.

8" f/6
$425.

6" f/8
$325.

All models shown with optional #637 6 x 30mm or #545 8 x 50mm viewfinders.

Compare *feature-for-feature* with other similarly priced Dobsonians!

- **Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass:** Unlike the plate glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians are made of Grade-A, fine-annealed Pyrex—the exact same professional-quality optics used on Meade Starfinder Equatorials.

- **Precision Components:** Including a full-size rack-and-pinion focuser (1.25") with 2.6" travel and fully-adjustable *4-vane* secondary mirror system.

- **Rigid, Durable, Beautiful Dobsonian Mountings**, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the location and tracking of celestial objects.

- **Optical Tubes:** Starfinder Dobsonians include the same strong, spiral-wound optical tubes used on Starfinder Equatorials *(right)*. All telescopes include a multi-coated MA25mm eyepiece; each tube is factory pre-drilled for the optional 6 x 30mm or 8 x 50mm viewfinder.

- **Performance!** A Meade Starfinder Dobsonian or Equatorial opens up the skies to an extremely wide range of serious visual observing: all 110 Messier objects, thousands of NGC objects—nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning, high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder equatorials may be used, in addition, for lunar and planetary photography and even for limited deep-space photography.

Packing and UPS Shipping Charges to any address in the 48 states: 6"–$39; 8"–$49; 10"–$69; 12.5"–$79. 16"–$45 packing, shipped truck freight collect.

ACCESSORY OFFER!

At the time you order any Meade Dobsonian, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, *and* the Meade #637 6 x 30mm viewfinder with metal bracket for a **total of $49.95!** *Purchased separately, the 2 eyepieces and viewfinder sell for $125.85!* Offer valid until further notice.

AUTHORIZED U.S. MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE COMPANY, Burbank, CA.
Orders & Information: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922.

FOCUS CAMERA, Brooklyn, NY.
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LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Illinois & Info.: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

STARF
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Computerize your Meade® Starfinder™ Dobsonian or Equatorial for only $295!

Spend your time **observing, not searching** for objects! **With the incredible Meade Magellan™ Telescope Computer System** attached to your Meade Starfinder Dobsonian or Equatorial, finding any of **12,218 celestial objects** is almost as easy as pointing the telescope.

- Don't spend $400, $500, or $600 for a computer system with fewer features! Designed and manufactured at the Meade Irvine facility, the Magellan I includes one of the largest object databases available, incorporates only premium-grade components, and sells for a low $295!

MEADE
ENTER
MODE
PREV
NEXT
ON
MAGELLAN I
TELESCOPE COMPUTER SYSTEM
U.S.A.

Actual Size: 4" x 5" x 1.25"

- **Easy to Use!** Just input the R.A. and Dec. of the object you wish to observe, or call up an object from Magellan's massive database. Magellan allows you to slew the telescope manually to the object and place it in the visual field, quickly and precisely.

- **Fast 2-Star Alignment:** Point the telescope at 2 bright stars selected from the star database, and the computer is aligned in *seconds.* No need to input time or date, latitude or longitude. Magellan's powerful microprocessor calculates telescope position in milliseconds and directs your movements of the telescope for fast, accurate object location.

Meade Magellan II Computer-Corrector for Starfinder Equatorials

Plug the Magellan II into the control panel of your Meade DC-powered Starfinder Equatorial *(right)* and you have *all the capabilities of the Magellan I (above)* ***plus*** a 4-speed, dual-axis, drive-corrector/microslewing system!

Includes: Magellan II hand controller *(right)* with 4 dual-axis speed rates (2x, 8x, 16x, 32x sidereal); high-resolution 4096-pulse encoders for both axes; electric Declination control system; 12,218-object computer database; 2-star alignment; RS-232 serial interface. (For Meade *DC-powered* Starfinder Equatorials, only.)

#2018: for Starfinder Equatorial
6", 8", or 10" . . . . $495.
#2019: for Starfinder Equatorial 16" . . . 595.

Prices plus $20 packing & shipping in the 48 states.

INDER
UTERS

■ **High-Resolution 4096-pulse Encoders:** Each Magellan system includes two premium-grade, high-resolution encoders. Encoder precision is 5.3 arc minutes.

■ **Large 32-Character LCD Red-Backlighted Display:** The same LCD display included with the Meade LX200 hand controller. Includes variable illumination from dim to bright.

■ **12,218-Object Database:** A database that includes an amazing array of objects:

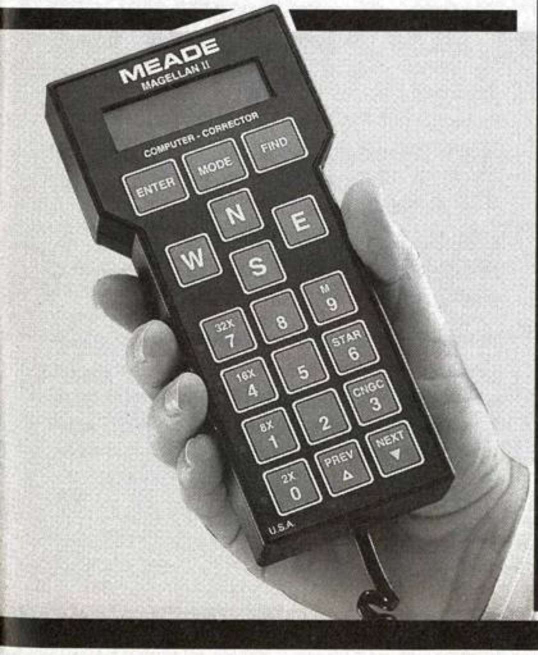
7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

■ **Supplied Complete!** With other computers you pay *once* for the basic controller and then pay *again* for the "Encoder Installation Package." Meade Magellan Systems are supplied **complete** with: controller/display unit (4" x 5" x 1.25"); encoders for both telescope axes; RS-232 serial interface; bracket for convenient placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan is ready to use. First-time installation is quick and simple.

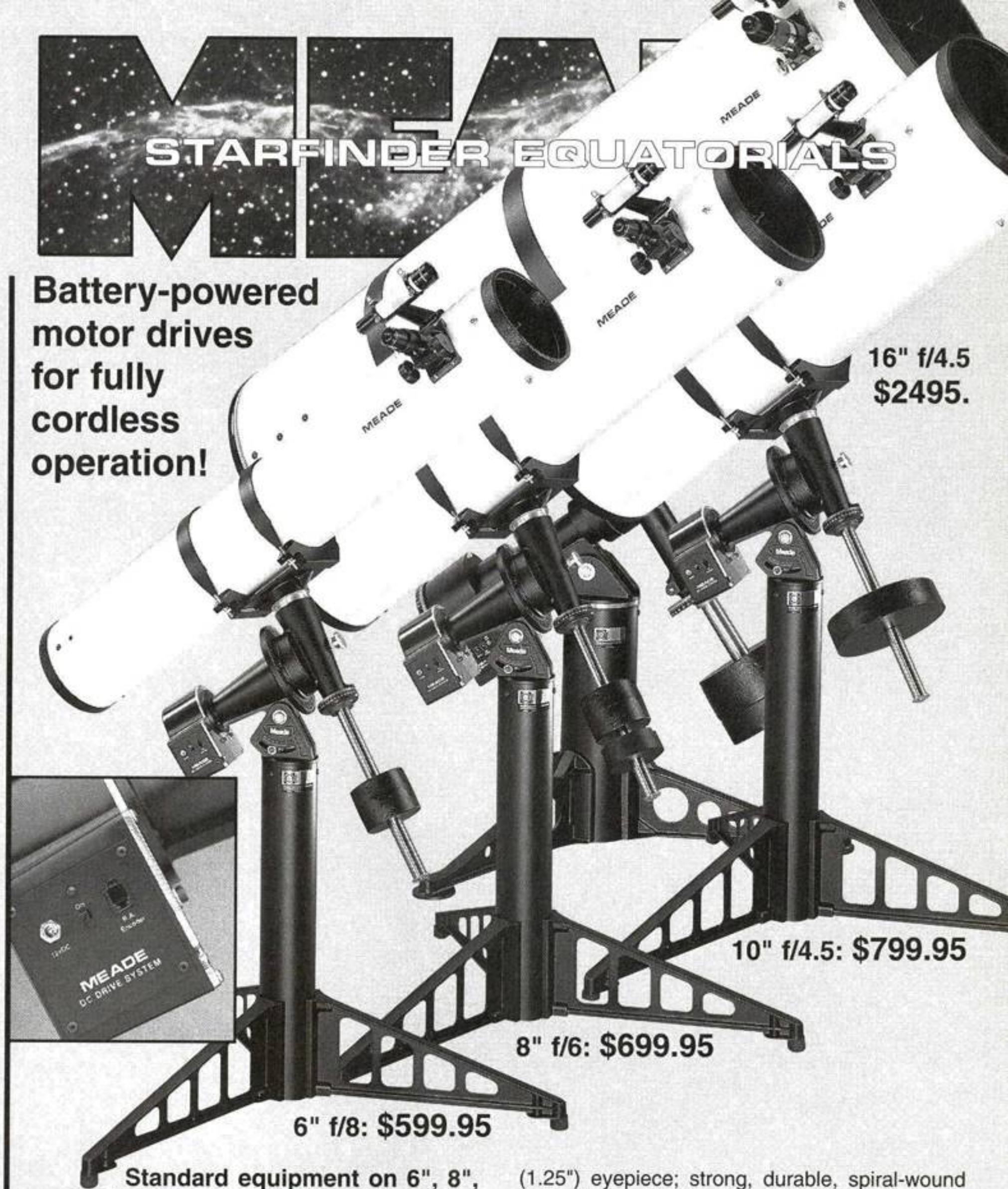
Meade Magellan I Telescope Computer Systems

#2010:	**for Meade Starfinder Dobsonian 6", 8", 10", 12.5", or 16"**	**$295.**
#2011:	**for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10"**	**295.**
#2012:	**for Meade (DC-powered) Starfinder Equatorial 16**	**295.**

All prices plus $15 packing & shipping in the 48 states. Prices shown are suggested U.S. national mail-order retail prices. For additional information on Meade Magellan systems, send for your free copy of **Meade Bulletin 2900.**



STARFINDER EQUATORIALS



Battery-powered motor drives for fully cordless operation!

16" f/4.5 $2495.

10" f/4.5: $799.95

8" f/6: $699.95

6" f/8: $599.95

Standard equipment on 6", 8", and 10" equatorial models includes:

■ **Superb Optical System:** Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

■ **Precision Equatorial Mount:** Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

■ **Battery-Powered Cordless Drive System!** Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 4 (user-supplied) AA-size batteries inserted through the drive cover. Control panel *(see inset, above)* also permits powering of telescope from 12v. auto cigarette lighter plug, using optional 25' cord.

■ **Accessories and Components:** Rack-and-pinion focuser (1.25") with 2.6" travel; #637 6 x 30mm viewfinder; multi-coated MA25mm (1.25") eyepiece; strong, durable, spiral-wound optical tube with attractive white finish.

■ **Starfinder Equatorial 16:** Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6"-dia. pier, 4 x AA-size battery-powered worm gear drive, 8 x 50mm viewfinder, #682 giant (2" & 1.25") rack-and-pinion focuser.

Packing and UPS Shipping Charges to any address in the 48 states: 6"–$65; 8"–$75; 10"– $90. 16"–$55 packing, shipped truck freight collect.

To Order: Contact your authorized Meade Advanced Products Dealer. All prices shown are suggested USA mail-order retail prices.

Meade 1995-96 General Catalog, $3.00 postpaid, is available from your authorized Meade dealer or directly from Meade Instruments.

ACCESSORY OFFER!

At the time you order any Meade Starfinder Equatorial Telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, for a **total of $29.95!** *Purchased separately, the 2 eyepieces sell for $75.90!* Offer valid until further notice.

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MEADE
MEADE 127ED/APO EMC
Meade LXD 650 U.S.A.
Meade

Meade Model 127ED:
5" *ED* Apochromatic Refractor.
Shown with optional #1697 Computer Drive System.

Background image: **the Omega Nebula (M17) —**
A 5-minute image by Jack Newton using the Meade 7" *ED* Apochromatic Refractor and Meade Pictor 1616 CCD Imager.

ED APOCHROMATIC REFRACTORS

"This is the best black-and-white CCD image of M17 that I have ever taken with any telescope. I just couldn't believe that this could be done in a 5-minute shot with a CCD camera and a 7" refractor. I'm amazed at how the telescope performs, even against my own 25" Newtonian." **—Jack Newton**

Fortunate indeed is the observer with a Meade *ED* Apochromatic Refractor at his or her disposal, for these are professional-class instruments capable of serious research. Observe structural detail and color variations within Jupiter's Red Spot and at the boundaries of 8 to 10 cloud belts; resolve all three of Saturn's main rings and substructures within the rings themselves. *Simply put, if you're looking for the finest, textbook-perfect, ultra-high-resolution, high-contrast imaging of the skies that astronomical instrumentation, of any type, can provide, then a Meade ED Apochromatic Refractor is for you.*

Use the massive Meade **LXD 650** (4", 5") or **LXD 750** (6", 7") equatorial mounts in conjunction with the optional **#1697 Computer Drive System** to slew the telescope across the sky and computer-point the instrument, automatically, *to a precision of one arc-minute.* ***Meade LXD mounts are the only commercially-available German-type mounts capable of such a feat.*** Actuate any of 9 pushbutton-controlled drive speeds (from 2x photoguide to 8°/sec. fast-slew) on both axes, automatically, to locate and center any object directly from its input R.A. and Dec. Or use the onboard database for even faster object centering. Included with the #1697 CDS, the Meade **Smart Drive**™ assures the extremely low periodic error essential to research-level photographic or CCD imaging.

More than 40 Meade optional accessories are available to suit virtually any observing, photographic, or CCD imaging requirement.

Supplied complete per catalog specifications:

4" f/9 Model 102ED	**$2495.**
5" f/9 Model 127ED	**2995.**
6" f/9 Model 152ED	**4495.**
7" f/9 Model 178ED	**5495.**
#1697 Computer Drive System	**695.**

Packing and shipping in the 48 states: 4"—$105; 5"—$125; 6"—$185; 7"—$215.

MEADE
MEADE LX200
MEADE LX200 EMC
MEADE LX200

16" LX200

Professional instrumentation for the demanding school, college, or university research program—or as the ultimate personal telescope for the advanced amateur.

Professional-grade 16" f/10 optical system meets or exceeds advanced requirements; includes BK7 correcting plate for high UV transmission and EMC super multi-coatings. ■ **Massive one-piece fork mount** permits substantial auxiliary equipment to be piggybacked with rock-solid stability. ■ **Large 11" worm gears** on both axes, with factory-programmed Smart Drive™; periodic error less than 5 arc seconds. ■ **Automatic GO TO capability** to any object in the onboard 64,350-object database or to any input R.A. and Dec. ■ **High-Precision Pointing™** to within one arc-minute in the GO TO mode. ■ **DC servo drive systems** with integrated encoders and planetary gearboxes; encoder resolution: 0.13 arc secs. ■ **Six pushbutton-controlled drive-speed rates,** from photo-guide to fast-slew on both axes, simultaneously. ■ **Micro-processor controlled sidereal-rate tracking** in AZ or EQ modes with quartz accuracy. ■ **Home-Pulse Acquisition** permitting remote alignment and operation through a modem link to the telescope's RS-232 interface. ■ **Control panel connectors** for optional systems including CCD autoguiders and imagers, electric focuser, and the Meade **#1222 Field De-rotater** for long-exposure astrophotography in the AZ mode. ■ Available with **supergiant transportable field tripod** (2-person field set-up in less than 10 minutes); **permanent altazimuth pier** (permitting the entire instrument to be housed in a 2-meter dome); or **permanent equatorial pier** (in cases where piggybacked astrocameras do not permit field de-rotation).

The Meade 16" LX200 is in continuous production at the Meade Irvine, Calif. factory. **Delivery time:** 4 to 12 weeks. **Price:** $14,950, complete with supergiant field tripod, plus $385 packing and shipping in the 48 states; prices slightly higher with permanent altazimuth or equatorial pier.

For your copy of the all-new **1995 Meade General Catalog** ($3.00), write Meade Instruments or contact your authorized Meade Advanced Products Dealer.

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Understanding the FFT

A slightly iconoclastic tutorial bringing a sometimes overly formal (even formidable) subject to laymen, students, engineers & serious amateurs. Available through your favorite local bookstore or directly from

Citrus Press
(407) 264-2200

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Titusville, FL 32783
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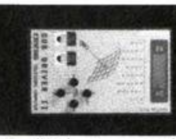
NEW!
DOB DRIVER II



Dual axis microstep quartz drive fits all Dobsonians, or user-built equatorials. Powerful computerized tracking, panning, and guiding in the palm of your hand! Super portable, super simple, AC/DC/CAR/BAT 12V. Instant setup-NO ALIGNMENT! Multi-function display. Calibration supertunes your scope to maximum performance. Options for PC link/CCD link/field-rot/DSC.
NEW SUPER-SMART SOFTWARE DOUBLES PRECISION!
Price Increase effective October 1st–HURRY!
Control only - $329 ATM System - $439
Complete system w/ready-to-install drives - $549
Free lit - satisfaction guaranteed!

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Monroeville, OH 44847
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LETTERS

— *John Henninger, Edmonds, Washington, bunky@ix.netcom.com*

Binocular Mount Built

I really enjoyed building the binocular mount (August 1995) and enjoy using it even more. Now I can sit in a chair or lay on a picnic table while the binomount holds my binoculars steady in any position I choose. It's a simple and efficient design that someone should commercially produce! — *Normand Cormier, Ville Ste-Catherine, Québec, Canada*

Livin' on the Astronet

Hooray for astronomy on the Internet! ("Blasting Along the Infobahn," June 1995.) Sometimes, here in cloudy Ohio, the only astronomy we can do is on the Internet. — *John Garret, Columbus, Ohio, jgarret@freenet.columbus.oh.us*

Congratulations on the Internet article. I especially enjoyed the mention of AstroWeb since I am a member of that consortium. Your readers may be interested in some other resources as well: StarWorlds (**http://cdsweb.u-strasbg.fr/starworlds.html**) is the largest database of astronomy, space, and related organizations, including more than 5,000, with more URLs than AstroWeb and data on thousands of organizations not yet on the Web. StarBits (**http://cdsweb.u-strasbg.fr/starbits.html**) is a dictionary of 85,000 plus acronyms and abbreviations broadly linked to astronomy, space sciences, and related fields.

StarHeads (**http://cdsweb.u-strasbg.fr/starheads.html**) is a database of 1,000 plus personal web pages of astronomers and space scientists. — *André Heck, Observatoire Astronomique, Strasbourg, France, heck@astro.u-strasbg.fr*

Amateur Astronomer ≠ Backyard Astronomer

I enjoyed the Behind the Scenes (July 1995) in which Robert Burnham laments the lack of "5-cent cigars" in the hobby of astronomy. I was a little upset, however, when he interchanged the terms amateur astronomer and backyard astronomer.

An amateur astronomer, as I see it, is really into the science. This person always looks for the newest telescope, the newest eyepiece, or the newest CCD camera. The amateur astronomer can sit for hours and extemporize on the big bang, black holes, quasars, or missing mass. The amateur astronomer really believes in the need for the parsec.

LETTERS

As a backyard astronomer, I am content with my 8-inch orange tube from Celestron and a couple hundred dollars' worth of accessories. I avoid getting caught up in the equipment frenzy or infected with aperture fever. I prefer viewing the sky with my eye and a telescope rather than on a computer monitor.

We backyard astronomers will probably never discover anything, but we'll be the first to nod in agreement when someone finally proves the big bang happened — it always sounded logical to us. We backyarders take in the universe as theater rather than theory. We're like the people who come to watch the race, not run in it. We're just glad to be sharing the stadium. — *Art Maurer, nansart@aol.com*

No More Starry Noise!

When one attends a rock concert, one expects to hear rock music. When one attends a folk music festival, one expects to hear folk music. When one attends a star party, one expects to see stars, not listen to new age music. That has happened to me at the last three star parties I've attended, the latest being the 1995 Texas Star Party.

Fans of new age music, with a self-righteousness equaling that of any fundamentalist religious cult, apparently believe it so clearly evokes the mood of the cosmos that everyone should be required to listen. Those of us who believe the music evokes the mood of a funeral in an elevator are heretics. Musical taste is, of course, purely subjective, and new age music has no more of a connection to the cosmos than any other style.

The only appropriate way for this or any music to be played at star parties is through headphones. That way, everyone who believes that music is an inspiration for viewing the heavens can enjoy their own brand. For many of us, the heavens are inspiration enough. — *Edward W. Szczepanski, Tomball, Texas*

Correction

The exposure times for lunar CCD images taken by Stéphane Dumont ("Are the Best Lunar Photographers French?" September 1995) were in the range of a fraction of a second each. ☐

ASTRONOMY welcomes feedback. Send your letters to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet, submit material to letters@astronomy.com. Letters may be edited for length and clarity.

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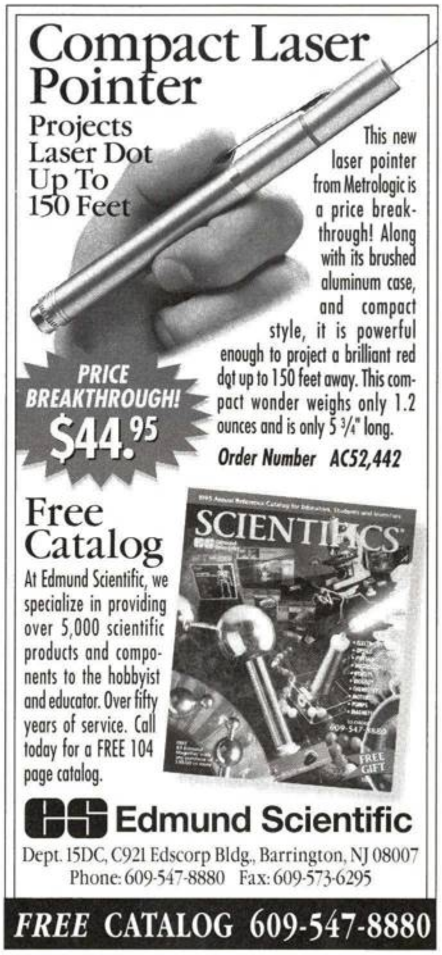

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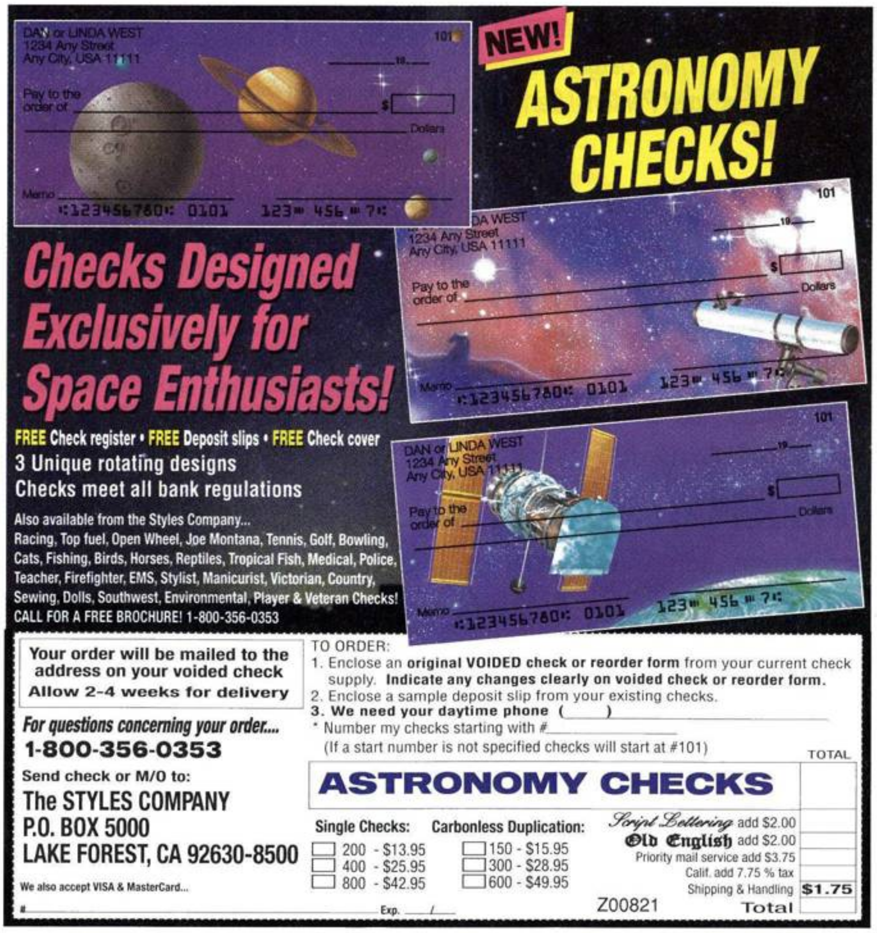

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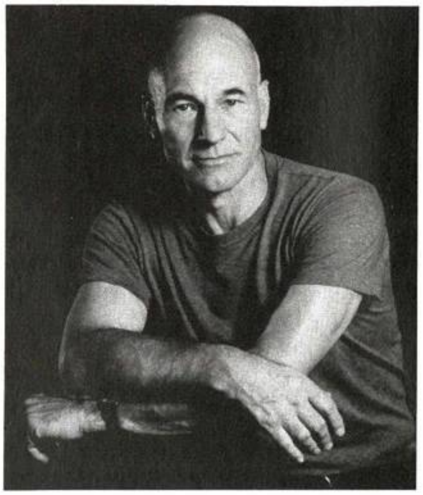
ASTRO FORUM

A Conversation with Patrick Stewart



Warren Betts

The actor who played Captain Jean-Luc Picard in Star Trek: The Next Generation discusses his new video "From Here to Infinity: The Ultimate Voyage," along with his burgeoning interest in astronomy and space exploration, with ASTRONOMY associate editor Robert Naeye.

What impact do you hope the video has on the general public?

This is a time when it's very important to reintroduce the public to what NASA is doing. I am particularly hopeful that young people will watch this video, because it touches on the great dream of exploration and discovery, and in that respect I think that it is outstanding.

Were you interested in astronomy and space exploration before you assumed the role of Captain Picard?

Yes, from an ordinary citizen's point of view. I can remember more clearly where I was when Neil Armstrong set foot on the moon than I can where I was when John F. Kennedy was shot. I remember that having an enormous impact on me. My son was then 4 months old, and I remember holding him up in front of the television and saying, "Look, pay attention to this, this is important."

When you were a child did you own a telescope, or did you have a moment of epiphany when you were suddenly overwhelmed by the night sky?

I did my fair share of lying in the grass at night and looking up at the sky. I have a house in a remote part of northern England where one has perfect conditions for stargazing. I had no telescope, but the people from my American fan club, to my amazement and delight, gave me a telescope for my birthday earlier this year, which I have shipped back to England. When I'm back in England I will be setting it up and pointing it at the heavens for the first time. I do remember very well the first time I looked through a powerful telescope. I was on a university campus in Ohio and people from the university who were fans of Star Trek had been asking me for some time to go out one night and look through the telescope. I was kind of putting them off because it just didn't seem to me that this was something that would be that interesting, and I was rehearsing a play. But then one night I went along, and they opened up the roof of the building and this chap fiddled around and did some focusing, and he said, "Have a look at this." And I was looking at a range of mountains in detail. I said, "I don't understand. What is this?" And he said, "You're looking at the Moon." So I said, "But I can see ridges and valleys." I was unprepared for how phenomenally bright and detailed it would be. Totally unprepared. And I remember I stayed until the early hours of the morning. I saw the rings of Saturn, and I looked at Mars for the first time. That's some of the stuff that I hope to be doing in a couple of weeks on my Yorkshire hilltop.

Are you hoping that people who watch the video might start to experience the night sky for themselves?

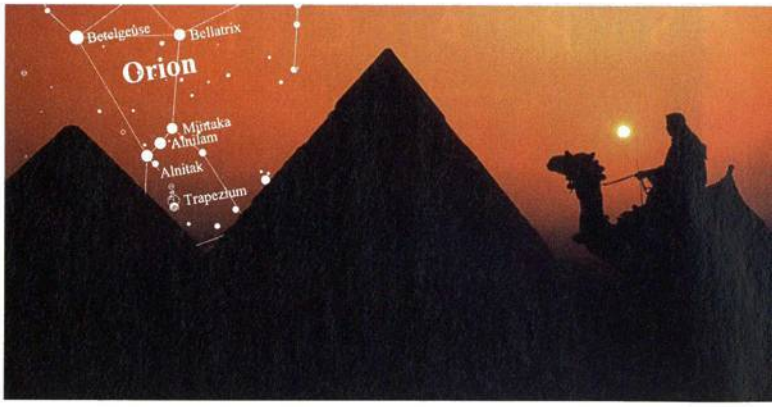
I think that would be tremendous. The fact of the matter is it's just there waiting for us to examine it. I thought this recent joint venture with the Russians and the Americans was so exciting. I have always been passionately interested in the whole idea of international cooperation in space. It seems to me that that's what we should be doing instead of seeing it as a kind of space race. We should all be working together.

In terms of the future of piloted space exploration, do you think in the future humans will step foot on Mars or even go to the stars?

Oh yes, I have absolutely no doubt about that. That is if we don't destroy

JACK NEWTON

CCD Astronomy: M27, as located, imaged and processed using TheSky Astronomy Software.



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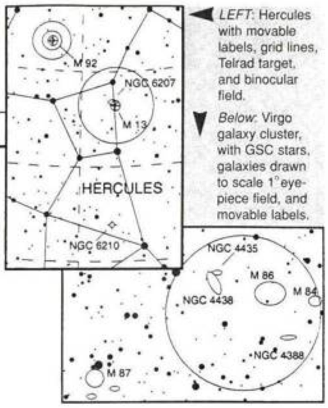

◀ *LEFT:* Hercules with movable labels, grid lines, Telrad target, and binocular field.

▼ *Below:* Virgo galaxy cluster, with GSC stars, galaxies drawn to scale 1° eyepiece field, and movable labels.

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this planet first, of course. There is a great deal of work to be done here, we must never forget that. Sometimes I wonder if we are the right people just now, if we are evolved enough to be going out into space — we are making such a mess of things here. I sometimes wonder if we should just straighten this out. Although I'm sure it will happen, it will probably not be in my lifetime. But nevertheless if ever there were an opportunity to experience some of that myself, I would certainly grab it.

In "From Here to Infinity," the spaceship of the imagination takes us to the outer planets, a pulsar, black holes, and Andromeda. If you could visit any place in the universe, where would you like to go?

I would love to go to a position somewhere in our solar system where one can view the Earth as truly a part of a star system and see it from an entirely outside point of view.

In the video you talk about planets, supernovae, and galaxies. Is there a specific area of astronomy or space exploration that particularly interests you?

What catches my imagination is the possibility of finding life forms out there. They're certainly there, there's no question of that. The simple mathematics requires us to believe that there are other life forms.

Surveys show that the American public is scientifically illiterate. What role can science fiction and shows like Star Trek play in getting more people interested in science, particularly young people?

It's one of the reasons that I'm so proud of what we've been doing on Next Generation. Any young person watching Next Generation will be exposed to the realities of science. Nothing on Star Trek was fantasy, even though some of it may represent much more advanced technology than we have at the present. It is all scientifically possible. And we've had many instances where young people have been very much turned on to science as a result of enjoying a TV show.

Science fiction has often anticipated new developments in science and technology. Are there any technologies on Star Trek: The Next Generation that you think might someday enter the realm of reality?

The one area in which scientists

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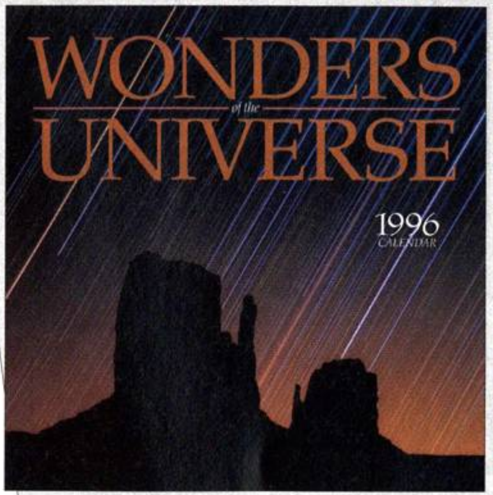

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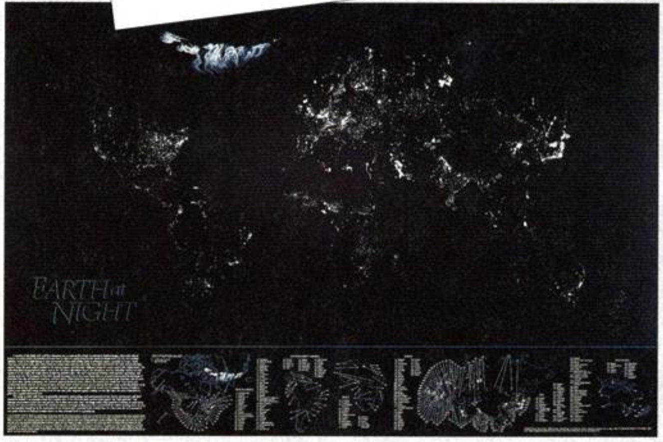

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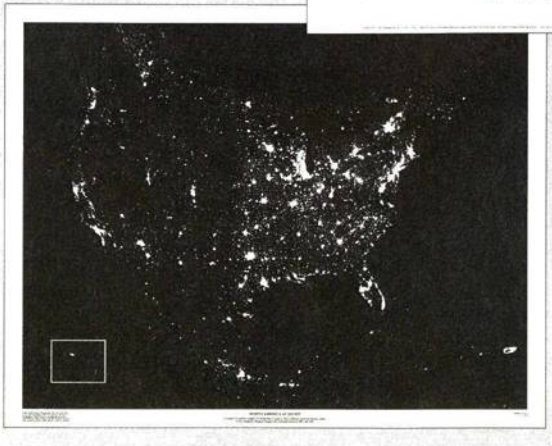

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would often be somewhat patronizing about Star Trek was the whole theory of warp drive. In fact, one of my most treasured possessions is a card belonging to Buzz Aldrin [the second human to walk on the Moon], who is a fan of the Next Generation. And Buzz had written on it something complimentary, and then he says, "But warp drive, never in anybody's lifetime." But there has recently been some research published which is suggesting that the idea of traveling faster than the speed of light may be a possibility. Arthur C. Clarke sent me a copy of this recent paper, published by an Englishman in fact, suggesting that warp drive may be a reality. That changes everything.

NASA's budget is currently declining from year to year when inflation is taken into account. Should we increase funding for space exploration even though we have all these problems on Earth?

I do feel very ambivalent about this. I would like to see our world survive, and I would like to see all of us evolve into better citizens of the world. And right now I don't think we're doing too well; though goodness knows we're in a better position than we were 10 years ago. And there have been times when I've wondered if we were the right people to be pushing out into space, given that we have made such a mess of things here at times. Are we old and mature enough to be out there? Should we not devote ourselves exclusively not only to improving the future of our planet, but also of adjusting our minds properly to the possibilities of exploring new worlds and finding new civilizations? In the history of this planet, whenever that's happened, the experiences on the whole have not been good. Exploration, exciting though it was, often brought considerable misery to a lot of people. And that gives me some concern.

Did you ever imagine that at some time in the future you might actually be playing the role of a cosmic traveler?

No. But there have been all kinds of spin-offs of this which have been immensely exciting to me. For instance, I was invited to record the wake-up call for one of the shuttle missions. The possibility that I would ever have done that was just unimaginable. I look on that as being one of the very great privileges that I have ever had, and that was directly as result of me being on a TV show. □

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ASTRO News

High Hopes for Hale-Bopp

Neil Trentham, University of Hawaii

HALE-BOPP BASKS IN THE SUN'S HEAT for the first time in almost 3,000 years. This picture taken on August 2 is a composite of three color-filtered images shot through the University of Hawaii's 2.2-meter telescope.

The more astronomers look at Hale-Bopp, the more it looks like the comet might shape up to be the best since 1976's Comet West. By late summer, a much-feared drop off in brightness had yet to occur, as happened with promising comets like Austin in 1990 and Kohoutek in 1973.

Long-period comets spend most of their time away from the Sun's heat. As these lumbering, dirty snowballs approach the Sun, their surfaces sublimate. Hopes for Hale-Bopp, which takes 3,000 years to orbit the Sun, remain high. Some observers are even taking comfort from a 1993 pre-discovery photo that shows the comet as an 18th-magnitude blob. The photo reveals that Hale-Bopp's nucleus had a level of activity similar to what was seen after the comet's discovery last July.

Brian Marsden, an astronomer who has tracked comet discoveries for more than 30 years, compares Hale-Bopp's characteristics to a bright naked-eye comet that appeared in 1811. Marsden suggests it might get as bright as magnitude –1.7 (Venus is –4.6 at its brightest) and sport a 15° tail by the spring of 1997.

Oblivious to all of the speculation, the comet lies in Sagittarius during December and January, hovering between magnitude 10 and 9.4 and too near the Sun to be seen until February. In that month's issue, ASTRONOMY will run a complete guide to observing Comet Hale-Bopp during 1996.

Owners of planetarium-type computer programs might find the following data released by Marsden useful

Coordinates for Comet Hale-Bopp

Date	R.A. (2000)	Dec.
December 1	18h34.7m	–26°34'
December 6	18h37.5m	–26°21'
December 11	18h40.3m	–26°07'
December 16	18h43.3m	–25°54'
December 21	18h46.3m	–25°40'
December 26	18h49.5m	–25°26'
December 31	18h52.7m	–25°11'
January 5	18h55.9m	–24°56'
January 10	18h59.1m	–24°41'
January 15	19h02.4m	–24°26'
January 20	19h05.7m	–24°10'
January 25	19h08.2m	–23°54'
January 30	19h12.1m	–23°37'

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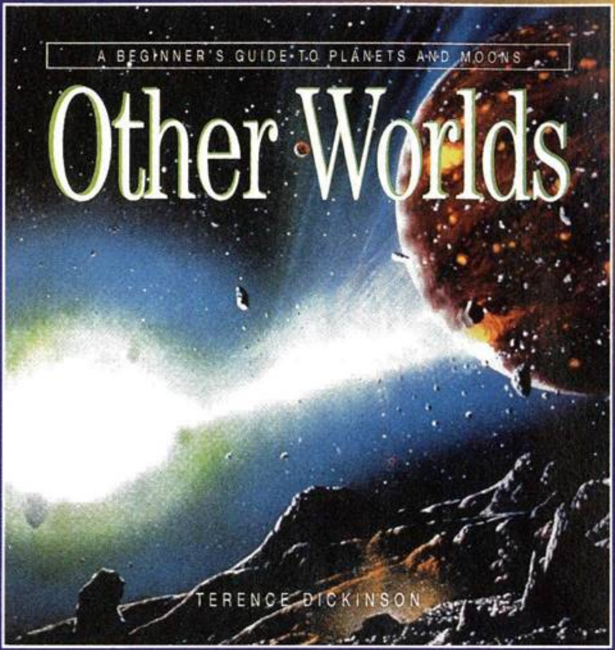
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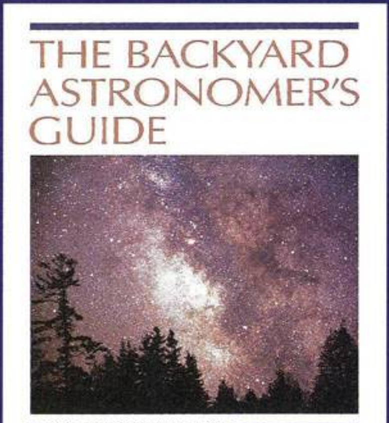
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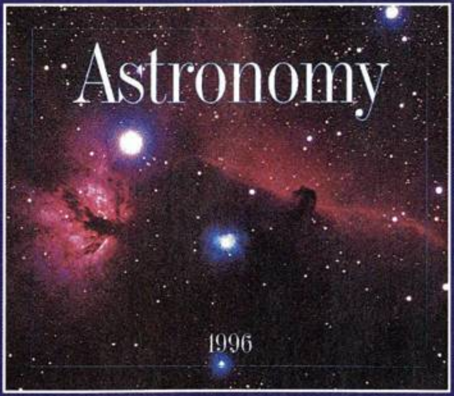
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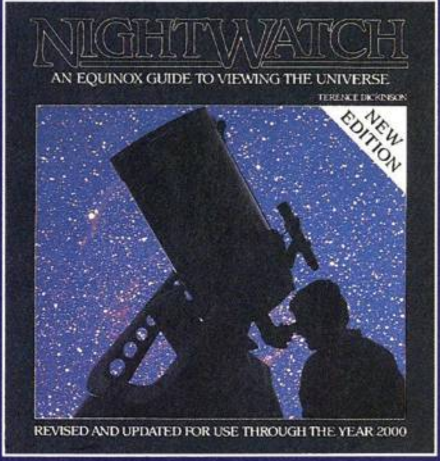
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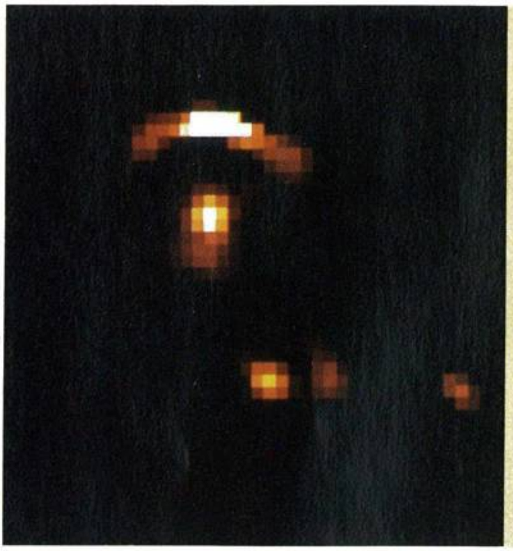
Solar System Dark Matter?

Prodigious quantities of dark matter pervade the universe, comprising more than 90 percent of all matter. Astronomers still don't know what this stuff is. But whatever it is, there's not very much of it in the solar system. A team of scientists from the Jet Propulsion Laboratory, the University of Texas at Austin, and Southern Methodist University in Dallas report in the August 1, 1995 *Astrophysical Journal*

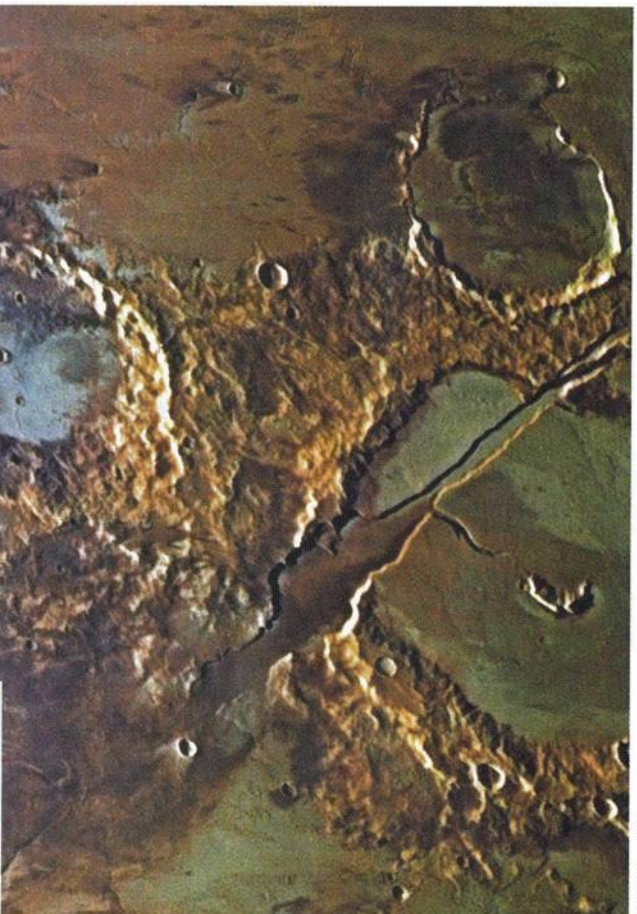


James R. Graham, University of California

SCORE ANOTHER GRAVITATIONAL LENS. Once dubbed the brightest galaxy in the universe, IRAS FSC 10214+4724 is actually bending the light of a more-distant galaxy or quasar into an arc. James R. Graham and Michael Liu of the University of California at Berkeley captured the sharpest images yet of the young galaxy using the 10-meter Keck Telescope in Hawaii.

Computer processing of the near-infrared image revealed that two objects, not one, exist along the same line of sight. The arc is produced from the light of a galaxy or quasar about 15 billion light-years away, and the smaller objects are galaxies that may be associated with IRAS FSC 10214+4724.

NEW VIEWS OF AN OLD RED PLANET. The Viking Orbiter spacecraft fell silent long ago, but careful processing and enhancement of its images are still yielding new geological insights about Mars. The complex colors in Memnonia Fossae (right) probably trace a sequence of lava flows, weathering, and wind-driven deposits of dust and sand. A region in Candor Chasm (below, left) that glows pink may indicate where hot springs have altered the rocks. The white deposit in Melas Chasm (below, right) may be evaporated carbonate minerals, while greenish tints mark areas of dark sand.



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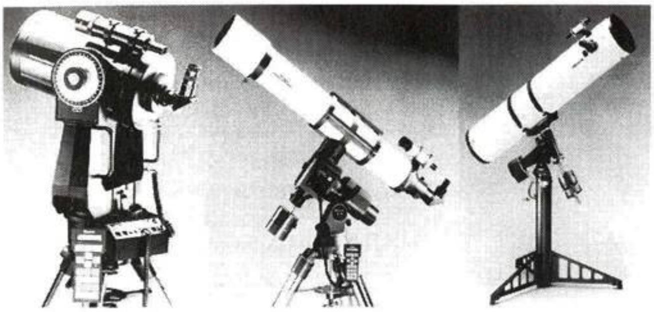

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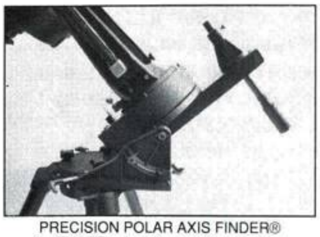

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that there's less than an Earth's worth of dark matter interior to Neptune's orbit, and less than one-sixth of an Earth mass interior to Uranus' orbit.

The team used ranging data from the 1989 Voyager flyby to determine Neptune's precise distance from the Sun. They next examined historical observations of Neptune and the other outer planets to determine orbital uncertainties. Once these uncertainties were known, they could calculate the total mass interior to Neptune's orbit that could possibly remain unaccounted for. Prior to the Neptune flyby the team had used Voyager Uranus flyby data to set less stringent upper limits on the amount of dark matter in the solar system.

Gravitational perturbations from the giant planets Jupiter and Saturn would have swept out almost all dark matter in the inner solar system. But these new results show there isn't much dark matter in the outer solar system either. "We have no evidence for dark matter that is trapped around the Sun," says Duane Dicus of the University of Texas.

The Milky Way's Feeding Frenzy

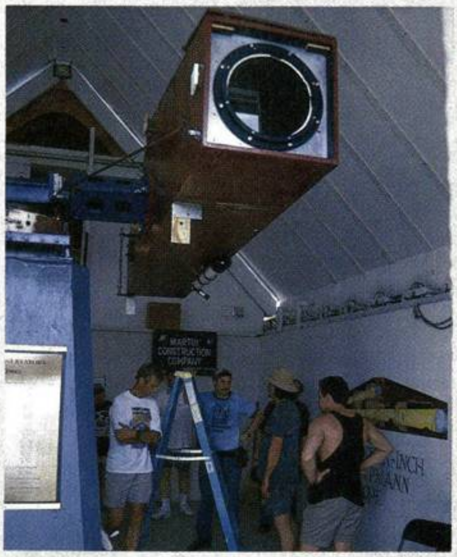
To a nearby dwarf galaxy in Sagittarius, the Milky Way is the proverbial neighbor from hell. Our home galaxy has ripped the dwarf to shreds and is feasting on its remains. Astronomers think the Milky Way has fattened-up by devouring other dwarfs in the past.

The galaxy, called the Sagittarius Dwarf, was discovered in 1994 by a team of Cambridge University astronomers led by Rodrigo Ibata. It is only 50,000 light-years from the galactic center, making it the closest

AMATEUR NEWS

Stellafane Survives a Downpour

Heavy rains drenched Breezy Hill on Friday evening, July 28, 1995, in the town of Springfield, Vermont. However, that didn't stop dedicated amateur astronomers and telescope makers from convening for the 60th Stellafane convention, the largest gathering of astro-hobbyists in the east. The following morning saw greatly improved weather as the rains moved off and more than 1,000 attendees surveyed the latest trends in telescope building, listened to specialized talks on telescopes, and enjoyed the recently completed McGregor Observatory, which houses a 13-inch Schupmann telescope.



ASTRONOMY: David J. Eicher

McGREGOR OBSERVATORY, dedicated on July 15, 1995, and named for Douglas McGregor, houses a 13-inch Schupmann telescope.

Scott Milligan's talk on Saturday afternoon focused on the fabrication of the 13-inch Schupmann. The telescope was built by Milligan, John Martin, and many other members of the Springfield Telescope Makers, the host club of the Stellafane convention. Martin's talk, which followed, summarized the construction of the observatory, which had been dedicated just two weeks before this year's convention began. The third of Saturday's talks was Stewart Rorer's discussion on how to optimize Newtonian telescopes for maximum performance.

The traditional Saturday evening ceremonies went off without a hitch and were highlighted by Phil Harrington's talk on the history of Stellafane. A legacy of 60 meetings produced a rich and amazing cache of images, which Harrington shared with the audience along with amusing stories associated with them. Watching the past six decades of amateur astronomy unfold on a screen below a starry sky made a relaxing end to what began as a thoroughly wet experience.

Planets Take Front Row in Wichita

Forty dedicated solar system observers gathered in Wichita, Kansas, last August a convention of the Association of Lunar and Planetary Observers. The annual gathering lets ALPO members share their observations and hear talks on a variety of topics.

One discussion centered on Jupiter observations, including those tracking blemishes left by last year's impact of Comet Shoemaker-Levy 9. Another session focused on the Moon, including surveys of intriguing lunar features called domes and ongoing lunar transient phenomena studies.

The convention wrapped up with a banquet talk, "The Solar System via the Hubble Space Telescope," delivered by Robert Landis of the Space Telescope Science Institute. The banquet also saw presentation of the Association's Walter H. Haas Observing Award to veteran Jupiter observer Elmer Reese.

Next year's meeting will be held in conjunction with the Astronomical League Meeting in Rockford, Illinois, on July 24-27, 1996. The public is invited to attend. For more information about ALPO or the meeting, write the membership secretary at P.O. Box 16882, Memphis, TN 38186-0882. — *John Westfall*

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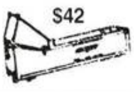

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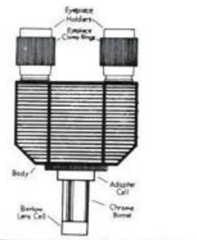

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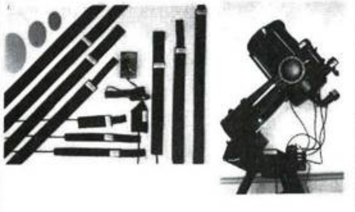

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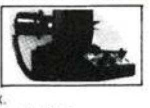

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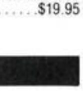

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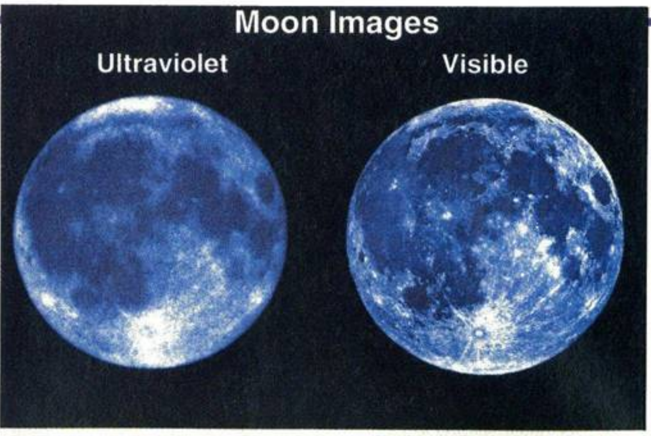
galaxy to the Milky Way. It was not discovered earlier because it lies on the opposite side of the Galaxy from the Sun, so its stars appear jumbled together with foreground Milky Way stars.

When Ibata's team discovered the galaxy they immediately noticed an elongated shape, suggesting that it was being tidally disrupted by the Milky Way's immense gravity. New computer simulations by Héctor Velázquez and Simon White of Cambridge show that the Milky Way has already shredded the dwarf. "We found that this dwarf galaxy was actually torn apart at its previous closest approach to the galactic center, about 50 million years ago," says White. "Most of the dwarf's stars are pursuing independent orbits around the Milky Way and are gradually drifting farther and farther apart."

Eventually the dwarf's stars will become indistinguishable from other stars in the outer reaches of the Milky Way. Many astronomers think that a large fraction of the stars in the Milky Way's boondocks originally formed in dwarf galaxies that were consumed in a similar fashion.They will continue to observe other galaxies to test this idea.



SRI (left), Lick Observatory (right)

BLUE MOON. Scientists got a surprise when they compared a new ultraviolet image of the Moon (left) with one taken in visible light (right): the lunar surface looks pretty much the same in both images. Compared to visible images, lunar UV images are more sensitive to rock freshness and should highlight regions that were resurfaced by impacts during the last 1 to 2 billion years.

Based on lab tests of Apollo samples, the scientists expected the UV image to be essentially a negative of the visible one. "That the Moon does not appear reversed in the UV is quite a mystery," says Randy Gladstone, head of the team that made the study. "We have our work cut out to explain it." Gladstone is at the Southwest Research Institute in San Antonio, Texas; the UV images were taken by Endeavour's Astro-2 payload in March 1995.

The Quasar Epoch

A new quasar survey has found that these distant cosmic powerhouses did not flicker on randomly. Instead, almost all quasars appear to have lit up at roughly the same time, which may tell astronomers when the first galaxies started to form (see "Fires at Cosmic Dawn," September 1995).

The survey, conducted by Maarten Schmidt of Caltech, Donald Schneider of Penn State, and James Gunn of Princeton, used the 200-inch telescope on Palomar Mountain in California to examine 90 quasars with redshifts between 2.7 and 4.7. A quasar's redshift is the amount that its spectrum is shifted toward the red as a result of the universe's expansion. The higher a quasar's redshift, the greater its distance from Earth, and the further back it existed in time.

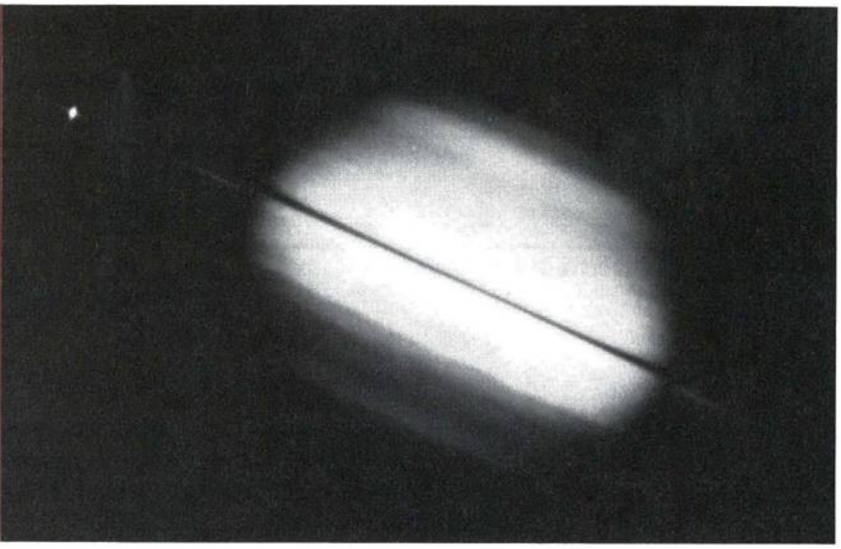
Previous surveys had shown that very few quasars have redshifts less than 1.7, but that many quasars have redshifts between 1.7 and 2.7. Schmidt and his team found that the number of quasars drops precipitously as the redshift climbs above 2.7, which means quasar formation reached a peak starting at redshift 2.7. The quasar epoch must have lasted from redshift 2.7 to 1.7, which corresponds to a period roughly 2 to 3 billion years after the Big Bang.

A typical quasar packs the energy of 100 Milky Way Galaxies into a region no larger than the solar system. Astronomers think this stupendous concentration of energy arises from a supermassive black hole in the core of a galaxy that has just collapsed from a giant gas cloud. If true, most quasars were lighting up at the same time the galaxies were forming. "Maybe 2 to 3 billion years after the Big Bang is the

SATURN'S THIN RINGS, tilted nearly edge-on to our line of sight, form a razor-sharp line in this image made with the Hubble Space Telescope on August 10, 1995. Such ring-plane crossings occur in groups every 15 years.

The visible moons are (left to right), Enceladus, Tethys, Dione, and Mimas. In late May astronomers found four new moons, and others may be spotted in Hubble's ring-plane-crossing images. "The Hubble data shows numerous faint satellites close to the bright rings, but it will take a couple of months to precisely identify them," says Steve Larson of the University of Arizona.

Phil Nicholson, Cornell, and NASA



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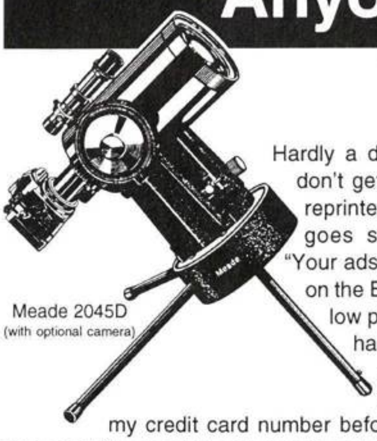

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The *new* Meade Advanced Products, Dobsonians, and accessories – *in stock!*

Whether it's a basic Meade like the compact 4" 2045D above; the latest LX50 or computerized LX200 7" Maksutov-Cassegrain; a 6" through 12.5" Dobsonian; or just a simple accessory like an eyepiece, a filter, a Barlow, or a camera adapter – if Meade makes it for a dealer to keep in stock, the chances are good we *have* it in stock.

Meade prices are usually the same anywhere you call. So there's no sense in buying from a dealer who takes your money (and sometimes takes more than he advertises), then makes you wait and wait until he gets around to ordering what you want. Not when you can get what you want *right now* . . . from ***astronomics.***

We have Meade and SBIG CCD imaging cameras – *in stock!*

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The new Celestron 8" Celestars, CG-9¼ and Ultima 9¼, and Ultima 11 – *in stock!*

We have Celestron's new cordless DC-drive Celestars in stock. They're the lowest-priced 8" Schmidt-Cassegrains made.

We have Celestron's new 9¼" Schmidt-Cassegrains in stock – both the fork-mount Ultima 9¼ and the Losmandy German equatorial mount CG-9¼. Each has 16% more resolution and 34% more light-gathering capacity than an 8" scope, plus DC-powered PEC drive corrector electronics, and a unique micrometer-readout knob focuser that makes precise CCD focusing a snap.

And, reintroduced by Celestron due to popular demand, we once again have Celestron's 11" fork-mount Ultima 11 in stock, too!

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We stock Telrads, too – and the Rigel Systems QuikFinder, the Rigel Systems variable brightness Starlite red LED flashlight, and the $4.99 Rigel Systems Aline collimating eyepiece.

Uranometria Volume 1 and 2 star charts are $39.95 each, and the Uranometria Deep Sky Field Guide is $49.95. *But* – buy any two and you save 10%! Buy any three, and you save 15%!

We stock the new TeleVue 1.25" 2x and 3x Barlows, and all the TeleVue eyepieces. The Pronto, Ranger, and Genesis-sdf, too.

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time the galaxies are being assembled," says Schneider.

Eta Carinae Wakes Up

Astronomers have discovered that the most massive and energetic star in the Galaxy, Eta Carinae, has over the past three years delivered a burst of energetic activity unlike any other previously observed.

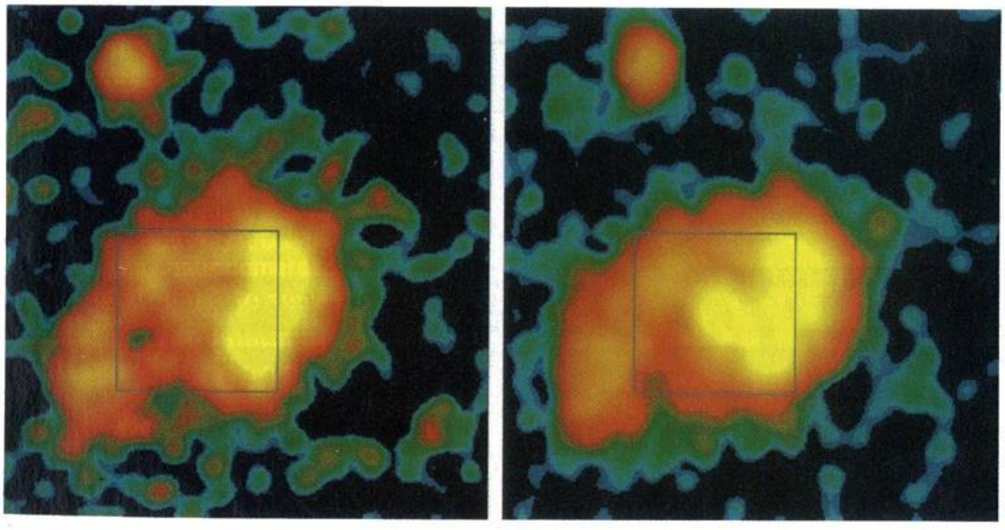
A group of researchers led by Michael Corcoran of the Universities Space Research Association studied X-ray images of the star from the ROSAT satellite. They found an extremely hot source of radiation located near the star that doubled its X-ray emission in only a four-month period.

"This variation is an entirely new phenomenon never before seen in Eta Carinae or any star like Eta Carinae," says Corcoran. "Although stars like Eta Carinae emit X rays, most seem to be fairly constant in their X-ray output. The burst we discovered is truly remarkable. Of course, Eta Carinae is a remarkable star."

Eta Carinae is a star located about 8,500 light-years from Earth. It contains about 100 times the mass of the Sun and generates about 6 million times the Sun's light output. The gas shell surrounding Eta Carinae expands over 4,000 times the size of the solar system.

The cause of the intense X-ray brightening can't yet be pinned down because it has been observed only once. The star may be ejecting mass into a dense cloud of dust, and the interaction may produce the X-ray energy.

Corcoran and his colleagues will continue monitoring the star to see if it is undergoing violent activity as it has during periods in the past, most notably in the 1840s, when it erupted and was for a time the second-brightest star in the sky.



ETA CARINAE SHOWS NEW LIFE in an X-ray image made in 1994 (right) relative to one made two years earlier. The massive star energizes a cloud of hot gas (yellow and orange), revealing a recent surge in activity.

Michael F. Corcoran, USRA and NASA

TECHNICIANS GINGERLY MANEUVER the first of two 5,000-pound nodes bound for International Space Station Alpha. Besides providing an area where space shuttles can dock, the nodes will also serve as connecting passageways to other modules in the station. Engineers plan to use this node for structural and pressure tests, then refurbish it for launch in September 1999.

Boeing Defense and Space Group

Subrahmanyan Chandrasekhar (1910 - 1995)

One of the great astrophysicists of the 20th century, Subrahmanyan Chandrasekhar, died at age 84 of heart failure on August 21, 1995, in Chicago. Chandrasekhar, better known as Chandra to friends, colleagues, and students, received the 1983 Nobel Prize for Physics for his 1930 calculations that led to the realization that massive stars may end their lives as either neutron stars or black holes.

Before Chandrasekhar's work, astronomers thought all stars ended their lives as white dwarfs. But Chandrasekhar showed that an imploding star's core with more than 1.4 times the mass of the Sun collapses beyond the white dwarf state into an object of such enormous density that "one is left speculating on other possibilities," he wrote. Astronomers call the 1.4 solar-mass threshold for white dwarfs the "Chandrasekhar limit."

"There is a total unanimity among astronomers that Chandra, as a mathematical astrophysicist, was the greatest of our generation," said astronomer Martin Schwarzschild of Princeton University. Chandrasekhar, born in Lahore, India (now part of Pakistan), spent the final 58 years of his life at the University of Chicago. From 1952 to 1971 he was the managing editor of the *Astrophysical Journal*.

Wait a Second

The new year will arrive a bit later than expected thanks to the gradual slowing down of Earth's rotation. A leap second will be added to the end of 1995 to help keep calendar time in close alignment with international atomic time. □

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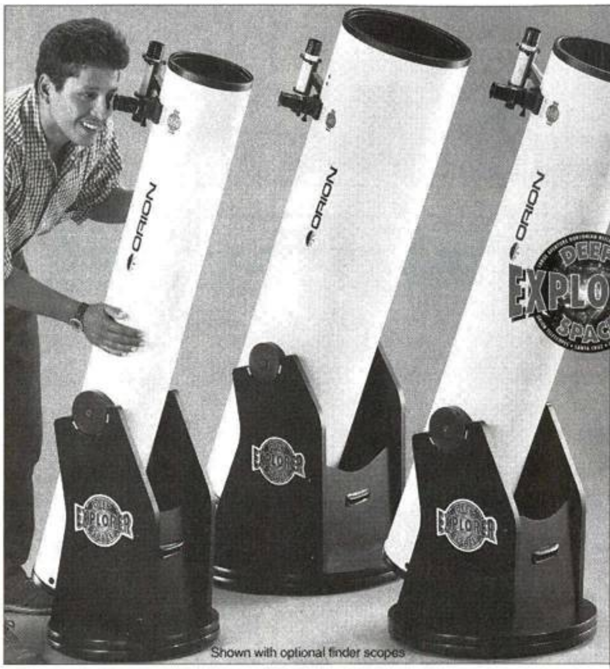

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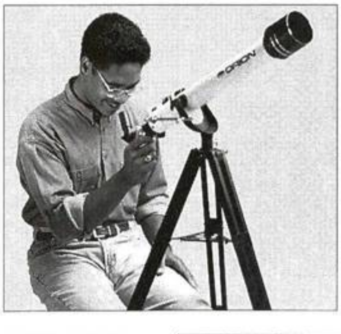

Observer 60 Refractor

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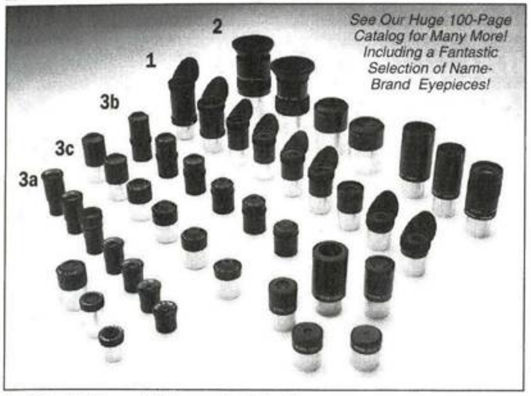
Eyepieces and Barlows



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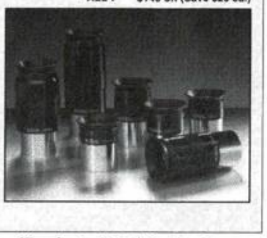

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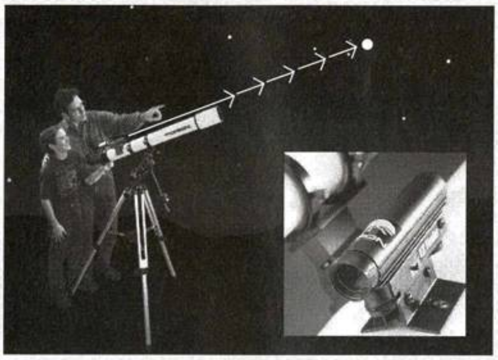

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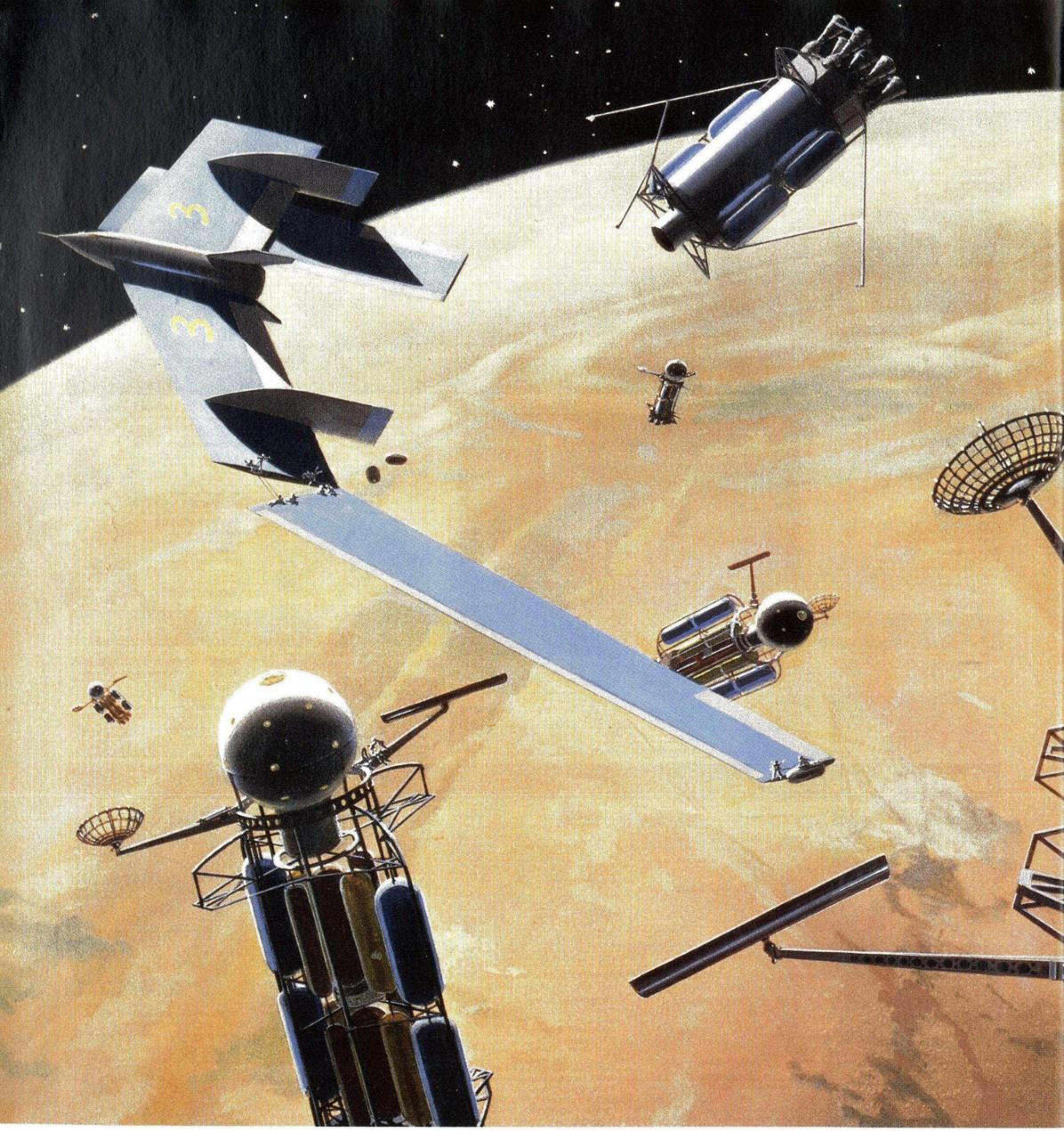
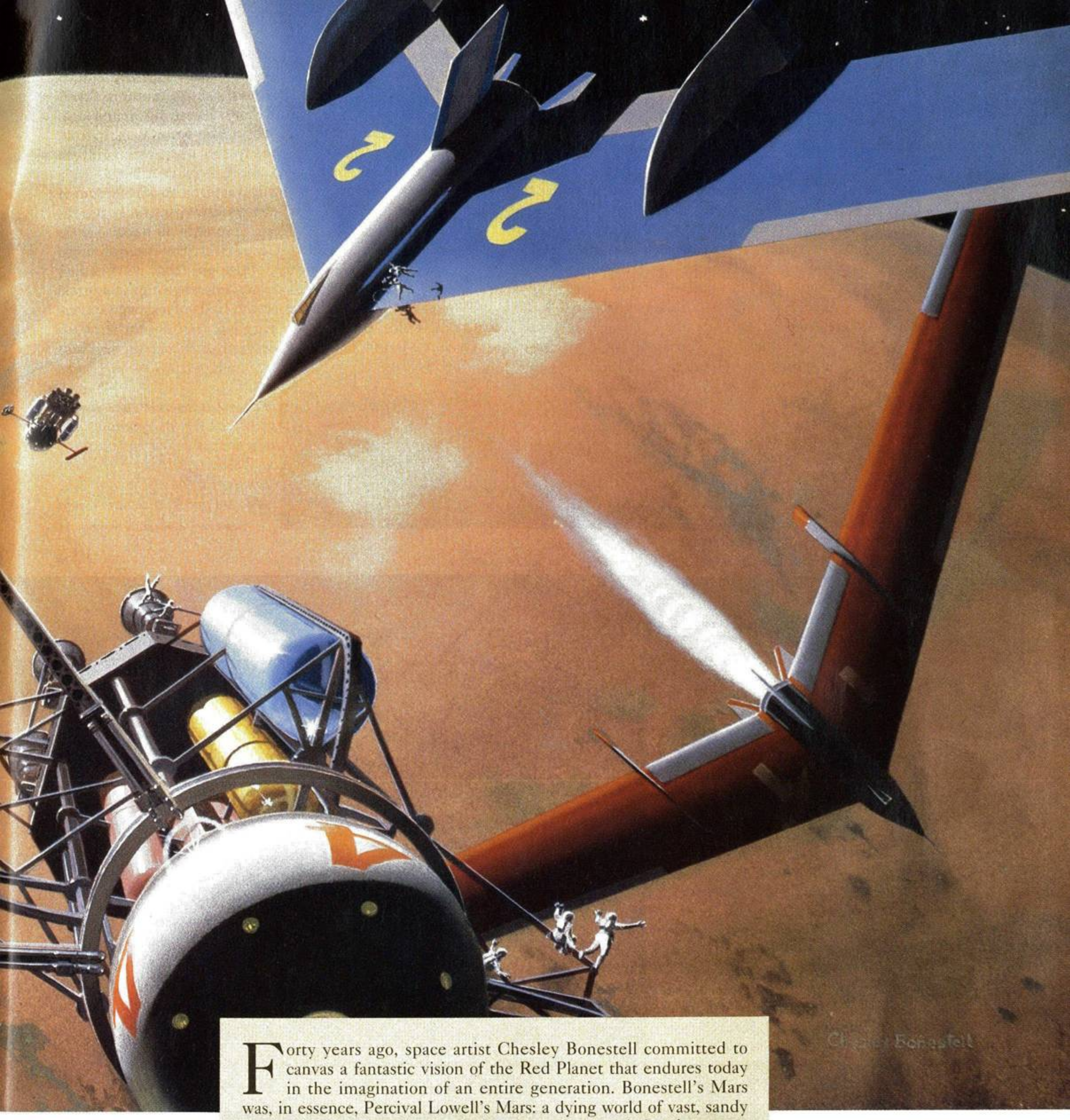


The Mars That Never

Return with us to the days of yesteryear when Mars was a planet of canals and wetlands, a possible habitat for primitive life, and where humans would one day boldly go.

by Edmund A. Fortier

Paintings by Chesley Bonestell



Was

Forty years ago, space artist Chesley Bonestell committed to canvas a fantastic vision of the Red Planet that endures today in the imagination of an entire generation. Bonestell's Mars was, in essence, Percival Lowell's Mars: a dying world of vast, sandy wastes, green vegetation, and planet-crossing canals bearing water from melting polar caps. It was a place a forward-looking humanity would explore in the not-to-distant future and, perhaps, even colonize.

To be sure, astronomers of the 1950s knew enough about Mars to suspect a harsh, topographically dull planet, but they also thought it might be hospitable to some kind of primitive life: lichens perhaps, or some other symbiotic algae/fungi organism clinging to the rocks along the edge of the polar ice caps. Even as late as the early 1960s some astronomers believed in the essential correctness of the Lowellian

EXPEDITION IN MARTIAN ORBIT (1953)
Winged spacecraft detach from a tanker supply ship. One spacecraft, at lower right, decelerates as it enters the Martian atmosphere.

view. After all, their theories were based on 350 years of telescopic observations and an impressive body of data.

The Mariner missions to Mars revolutionized our ideas about the Red Planet. When Mariner 4 swept past Mars in July 1965, its cameras revealed a craggy, crater-scarred landscape. For astronomers and the public at large, it was a startling discovery. The next two spacecraft in the series — Mariners 6 and 7 — did little to change the initial picture: Mars was an arid, dusty, desolate world. But Mariner 9 (the first orbiter) and Vikings 1 and 2, with orbiters and landers, started changing scientists' views. Mars was (and still is) lifeless, yet it's clear that rivers have flowed and perhaps even oceans once existed there.

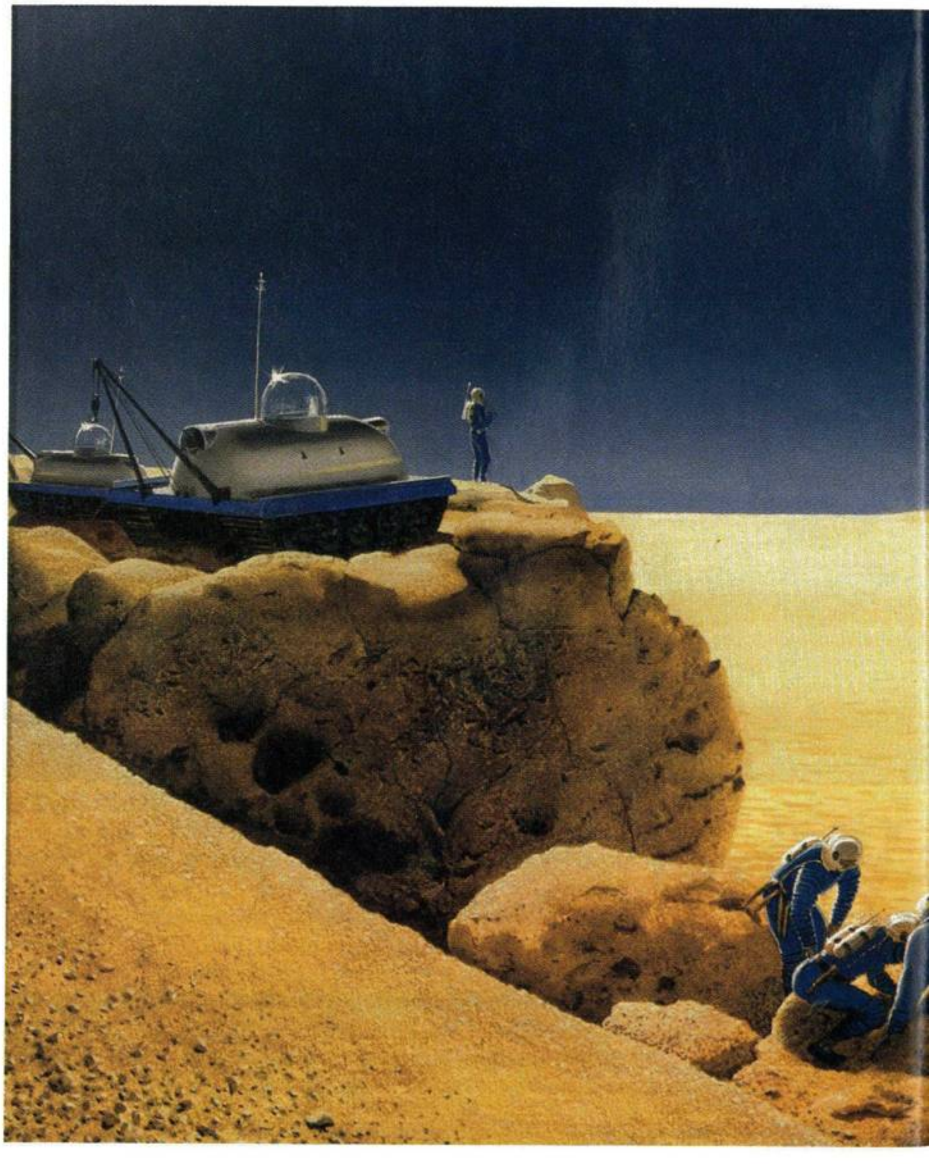
Forty years ago, however, all that still lay in the future. A look through the pages of any pre-Mariner book about the Red Planet reveals just how misleading the early telescopic data was. Typical of such books is *The Exploration of Mars* by the German-American rocket engineers Willy Ley and Wernher von Braun. Published in 1956, this handsome volume traces the history of Martian studies, recaps the latest theories on surface conditions, and outlines the mechanics of a manned Mars mission. Included among its many illustrations are twenty-one paintings by the renowned space artist Chesley Bonestell, sixteen of them in color.

In the 1950s much of what astronomers believed about Mars was based on visual, radiometric, and spectroscopic analyses. Because atmospheric turbulence blurs fine planetary detail, photography was of limited use in recording what the eye detected, and technologies such as charge-coupled devices and digital enhancement were still decades away. So while the debate over intelligent life on Mars was long over, the question of the canals — a gridwork of fine, dark lines that had been reported from time to time crossing the planet's ochre surface — remained unresolved right up until the Mariner missions.

On the subject of the canals, *The Exploration of Mars* is a model of mid-century optimism. Ley and von Braun acknowledge that skilled observers like Asaph Hall and K. Graff never saw a canal, but they are firmly on the side of those who had — Giovanni Schiaparelli, William H. Pickering, and Percival Lowell. Why had the canals eluded Hall and Graff? According to the authors, "seeing" was the likely culprit. Graff, working near Hamburg, Germany, and Hall, observing from Washington, D.C., simply lacked the steady skies of Schiaparelli in Milan, Pickering in Jamaica, and Lowell in Arizona.

Another argument in support of the existence of canals was that observers always drew the most prominent ones in the same places. The authors have so little enthusiasm for Vincenzo Cerulli's explanation of these features as "induced optical illusions" (that is, very fine and roughly linear detail perceived as continuous lines) that they reject his theory on the basis of a flawed experiment conducted by the English astronomer Edward Walter Maunder back at the turn of the century. Their conclusion:

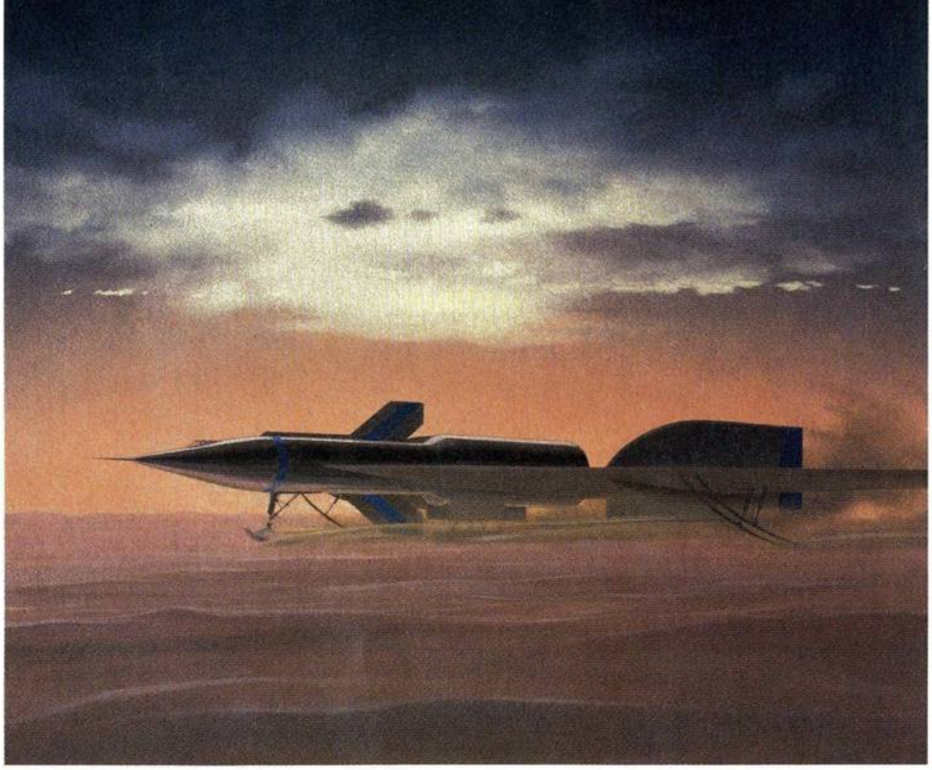
> *"The fact remains that the canals, whatever their true nature may be, are exclusive to Mars. And as for 'imagination' and 'wish fulfillment,' the best answer is a frank statement by Robert S. Richardson of Mount Wilson Observatory: 'If wishful thinking could conjure up canals, I'd have seen them long ago.' But it took him until 1954 to see one with certainty, and probably two others.*



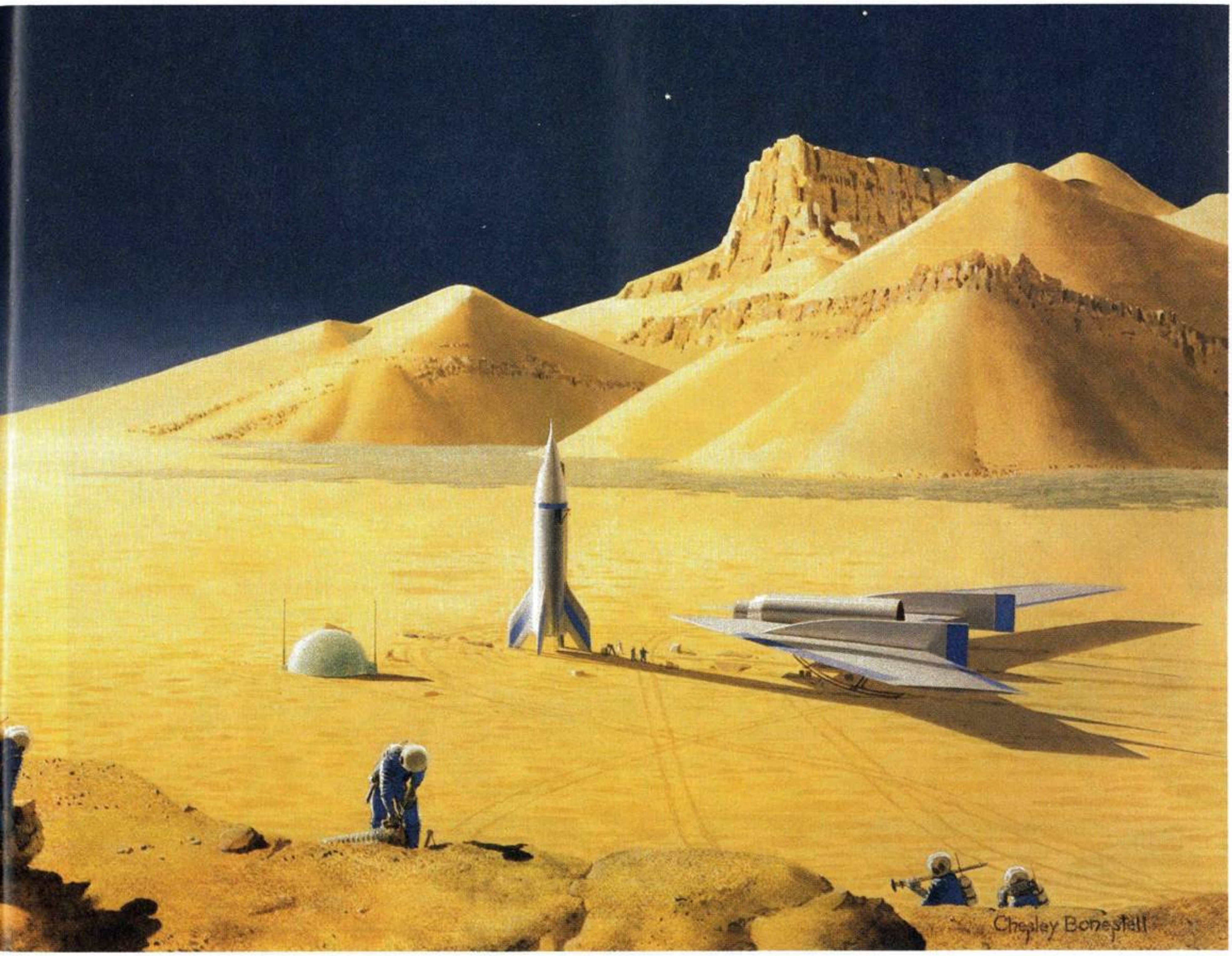
ASTRONAUTS EXPLORE THE RED PLANET. With the base established, and the nose of the landing craft detached and erected in preparation for return to Martian orbit, the astronauts can begin to explore the landing site.

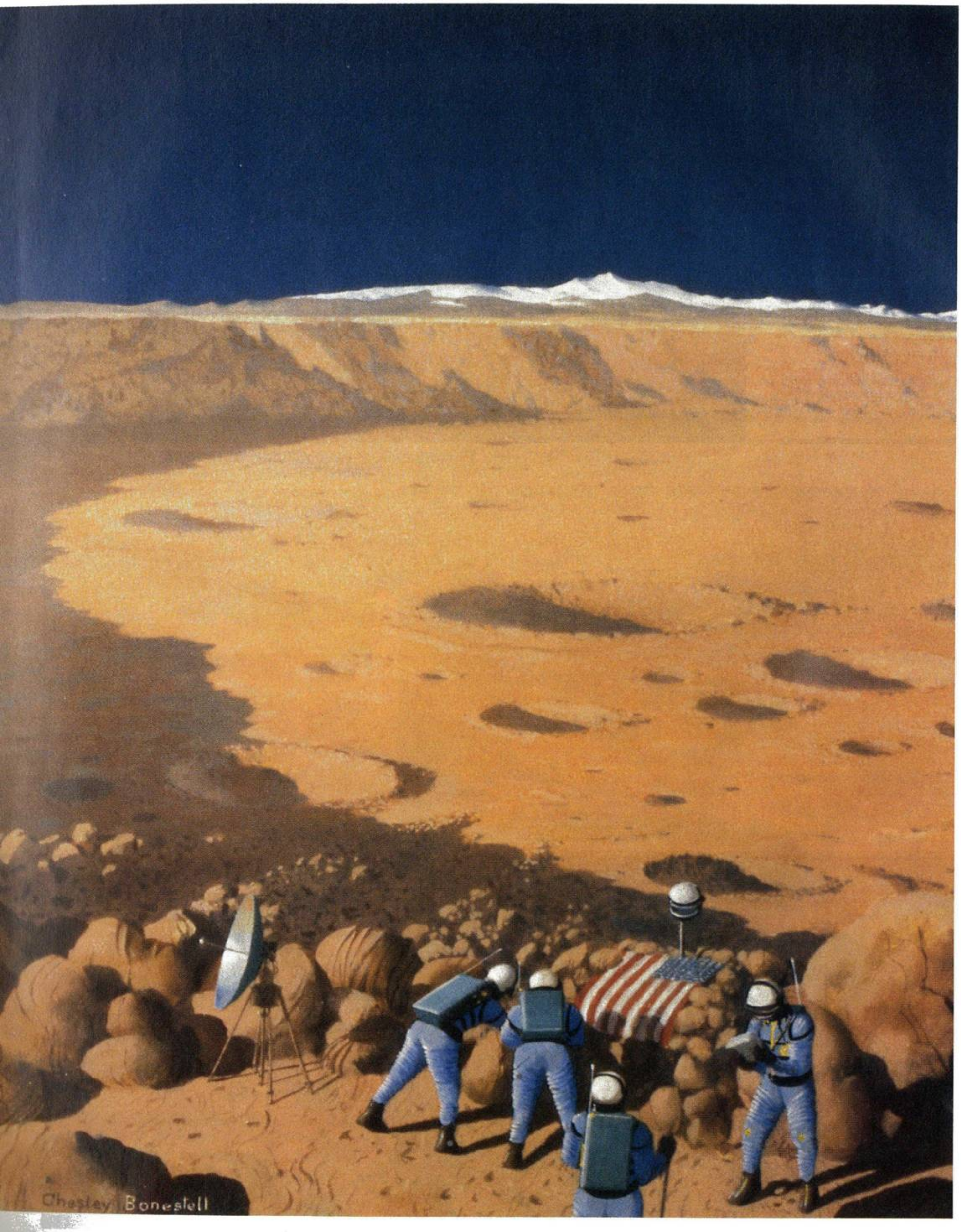
To judge by *The Exploration of Mars*, the question of the canals was about the only issue dividing planetary scientists. To be sure, there was still much to learn about the planet next door, but in general astronomers were confident they had pieced together a reasonably accurate picture.

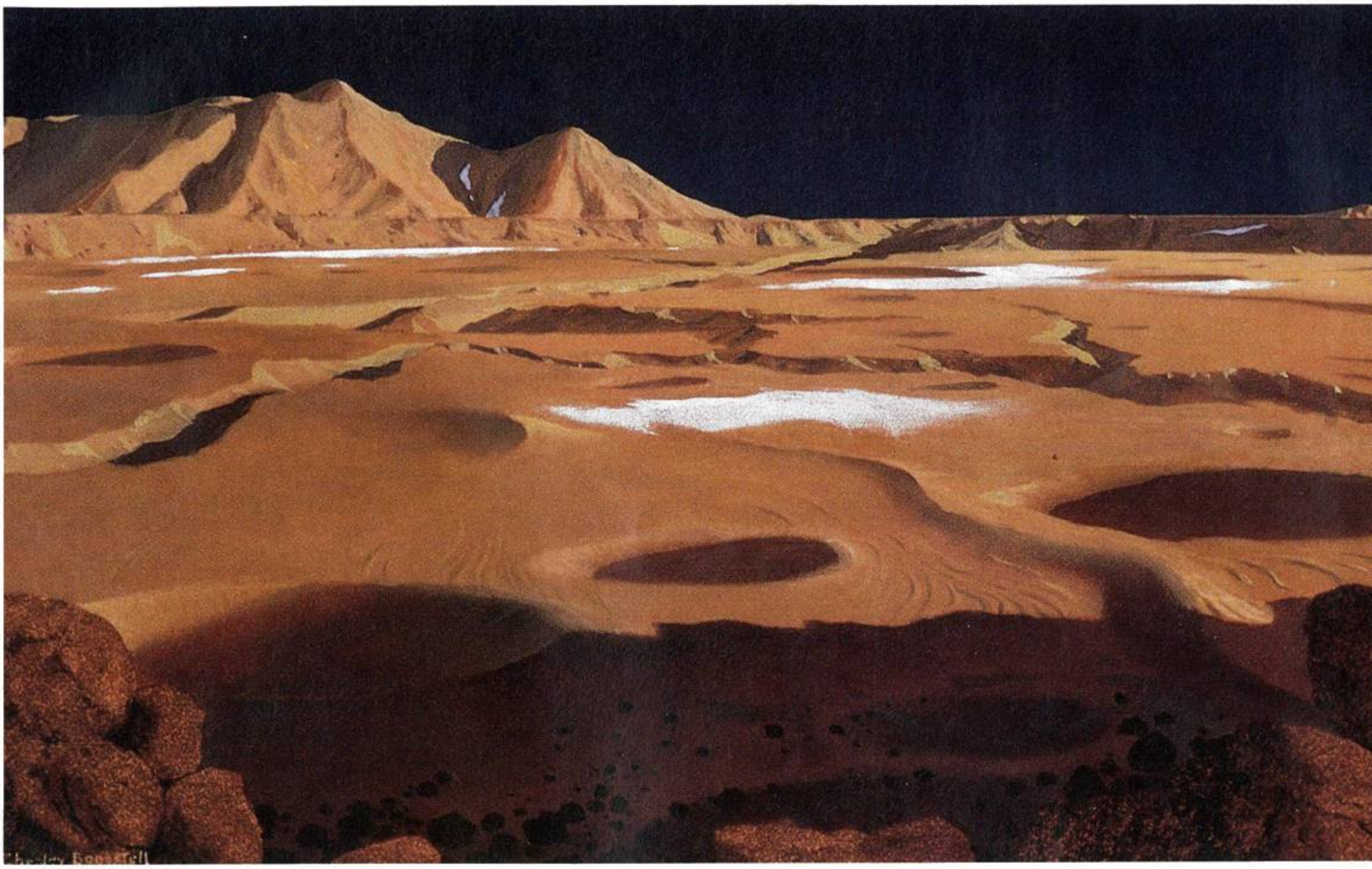
What's more, that picture was an encouraging one. For example, day-



TOUCHDOWN! The first piloted winged spacecraft lands on Mars.




Chesley Bonestell



CASUALTY OF A HOSTILE ENVIRONMENT, astronauts bury their dead on Mars.

A SEPARATE MARTIAN REALITY, a frozen desert crisscrossed by natural valleys and low frost fields.

time surface temperatures, if not exactly balmy, were at least tolerable. Noontime desert temperatures were thought to range from about 14 to 41 degrees Fahrenheit; the noontime range in the dark areas — presumed to be low ground — was 50 to 68 degrees. Of course, the night side of the planet was bitterly cold, averaging perhaps 94 degrees below zero. These measurements, made at Lowell Observatory during the opposition of 1924, were still regarded as reliable in 1956.

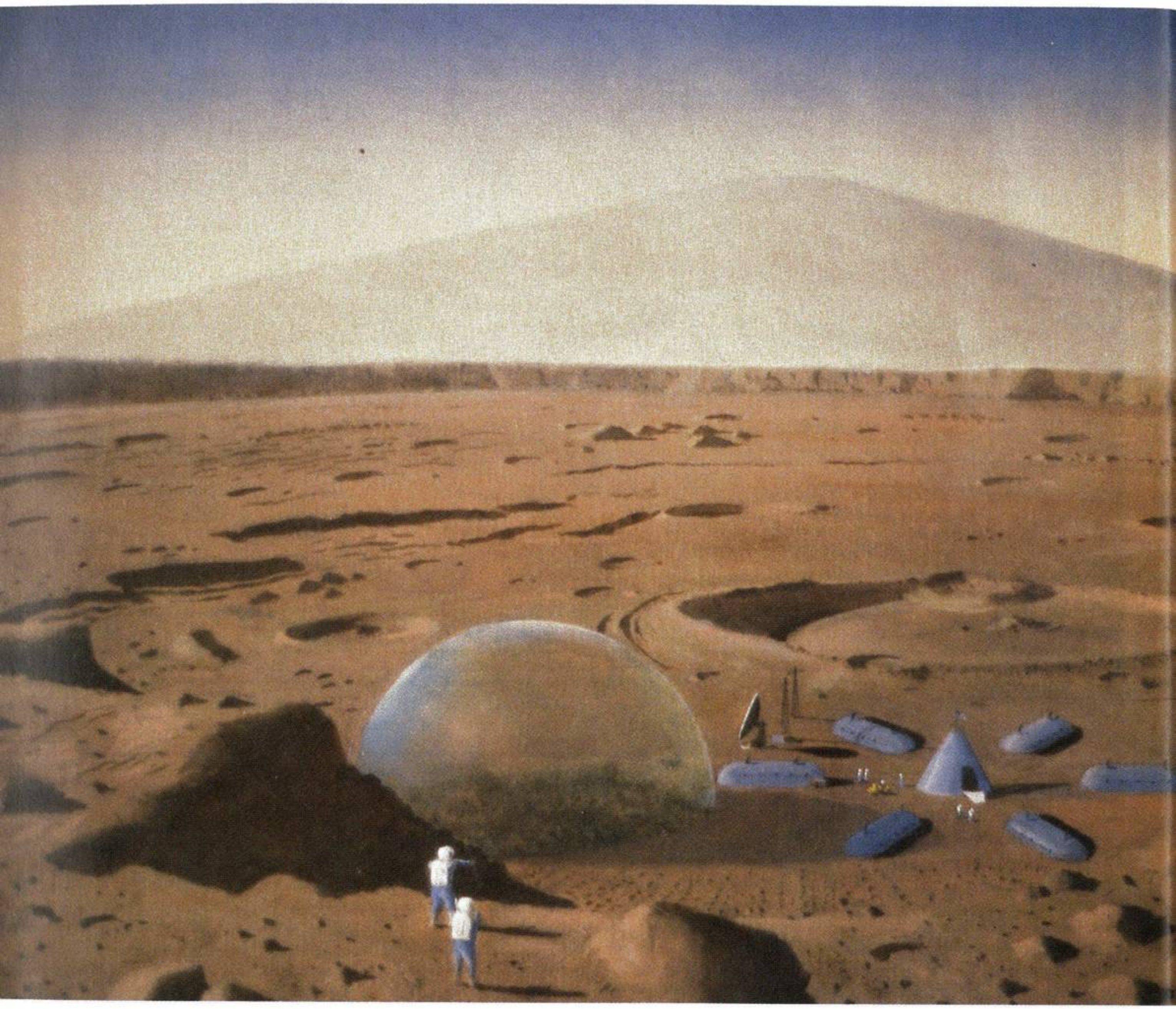
Atmospheric pressure was also believed to be significantly higher than present-day values. "The best determinations," the authors report, "permit the conclusion that the pressure at the surface is somewhere between 62 and 70 millibars of mercury, which corresponds to that of a height of between 16.5 and 17.5 kilometers (10.3 and 11 miles) in Earth's atmosphere." Thin, but not quite as rarefied as the approximately 8 millibars of atmospheric pressure measured by the Viking landers.

Determining the composition of the Martian atmosphere proved particularly troublesome. The best estimate was that it contained 96% nitrogen and 4% argon, with traces of water vapor and carbon dioxide. ("The presence of carbon dioxide has been shown by the spectroscope; in fact, the percentage of carbon dioxide in the Martian atmosphere is higher than in the terrestrial atmosphere.") Today we know that the Martian atmosphere is 95% carbon dioxide with only about 2% to 3% nitrogen and even less argon.

Martian clouds fell into one of two categories — yellow clouds of airborne dust and white clouds composed of ice crystals. However, large gray clouds had occasionally been spotted, confirming the existence of active volcanos on the planet.

In their discussion of Martian surface features, Ley and von Braun describe a world that, in its topography at least, is not fundamentally different from Percival Lowell's Mars. The polar caps, most astronomers agreed, were indeed frozen water. The only major disagreement was over just how thick the caps were — estimates ranged from 1/10 of an inch to 10 inches — and whether or not they were composed of snow or ice. On the last point the authors, citing a Russian study conducted during the opposition of 1939, opt for ice covered by the feathery, frozen dew known as hoarfrost.

Astronomers had also determined the nature of the dark fringe that was sometimes observed along the edges of the polar caps. This feature was thought to be either moist ground or, as seemed more likely, a contrast effect caused by the brilliance of the ice cap. Later, the French-American astronomer Gerard de Vaucouleurs,



A BASE ON MARS. In the distance rises a broad-based shield volcano.

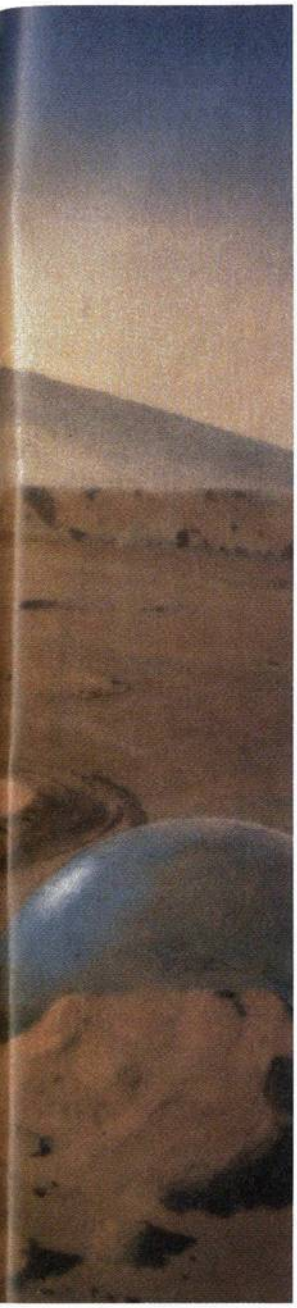
after repeated observations, concluded that it was indeed moistened soil. The polar ice really did melt — but only after a great deal of evaporation had taken place.

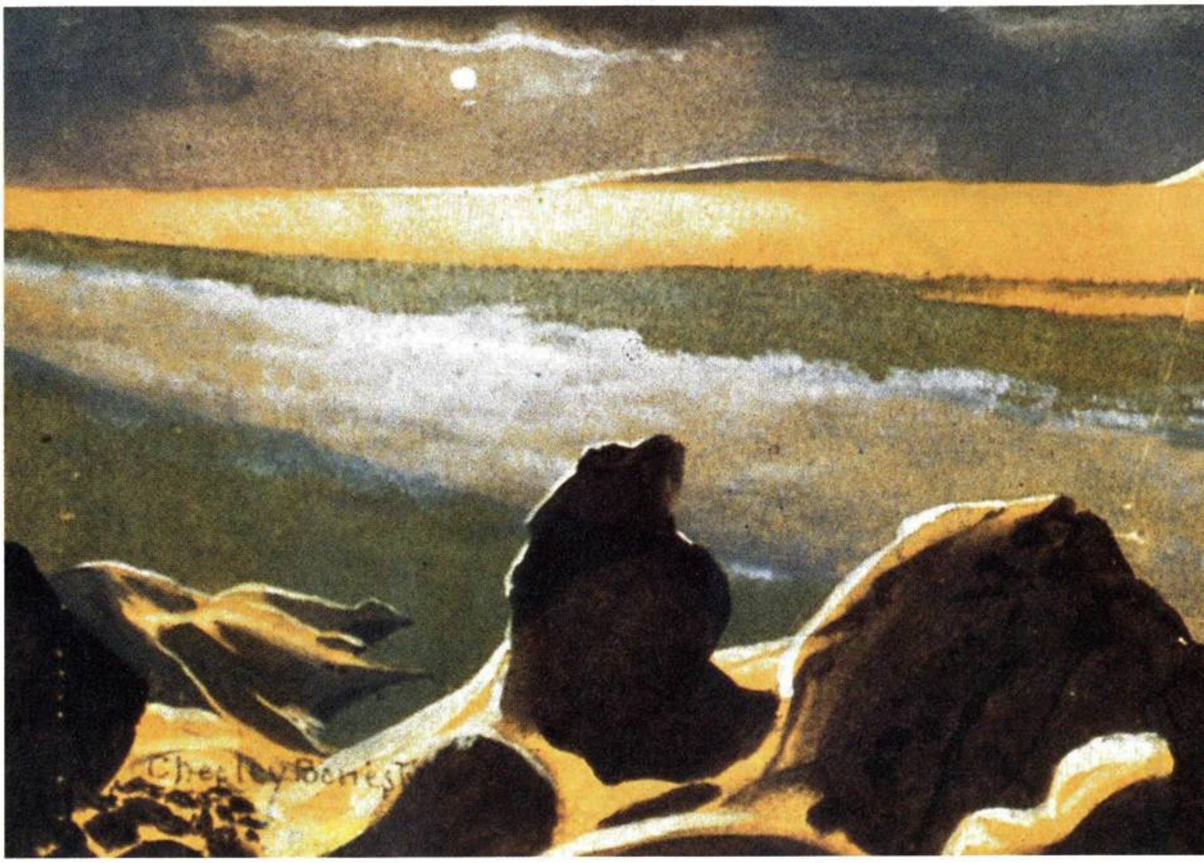
Interestingly, the Red Planet's most conspicuous surface feature is glossed over in one short paragraph:

> *"Physically the most extended feature of Mars is, of course, the desert which covers three-quarters of the surface. Except for Baumann and a few other theorizers who followed more or less in his footsteps, there has never been any serious disagreement about its nature, namely that it is desert colored by a fairly high percentage of iron compounds, a large part of which may even have come from space, as Arrhenius thought."*

Such a brief account indicates the limitations of Earth-based observations. Canals aside, surface details were just too faint and too fleeting for Mars observers to imagine these reddish areas as anything other than flat, rather bland, planet-wide deserts.

By far, the Red Planet's most intriguing surface features were the so-called "dark areas." While long regarded as vegetation, there had never been a satisfactory response to Swedish chemist Svante August Arrhenius' contention that they represented hygroscopic color changes caused by moisture. That explanation, according to Ley and von Braun, had recently been given by Russian astronomer E. J. Opik. If Arrhenius' theory was correct, Opik argued, the dark areas should have been covered over by dust storms long ago. Yet these markings always reappeared after such storms, which meant they could only be something with the





A FOGBOUND MARTIAN CANAL, another aspect of a Mars that never was. Some astronomers thought that if canals existed, they were long, low valleys or faults in the planet's crust.

power to break through the dust — something alive.

But what kind of vegetation? The authors, weighing the relative merits of mosses and lichens, make the case for lichen-type vegetation. Unlike mosses, they point out, lichens can flourish on bare rock and in any climate or altitude. Moreover, they have no root system and extract moisture directly from the air. Still, Martian vegetation need not resemble lichens either in shape or structure. There was no way to tell, across 35 million miles of space, "just what biochemical tricks have evolved under Martian conditions."

Other possibilities existed too.

> *"...the dark areas, constantly breaking through covering dust, and even expanding on occasion, do not look like the 'last foothold of life,' as they have been described. Instead, they look rather vigorous — and it is very hard to admit the existence of large areas of vegetation and in the same breath to deny the possibility of creatures that eat those plants."*

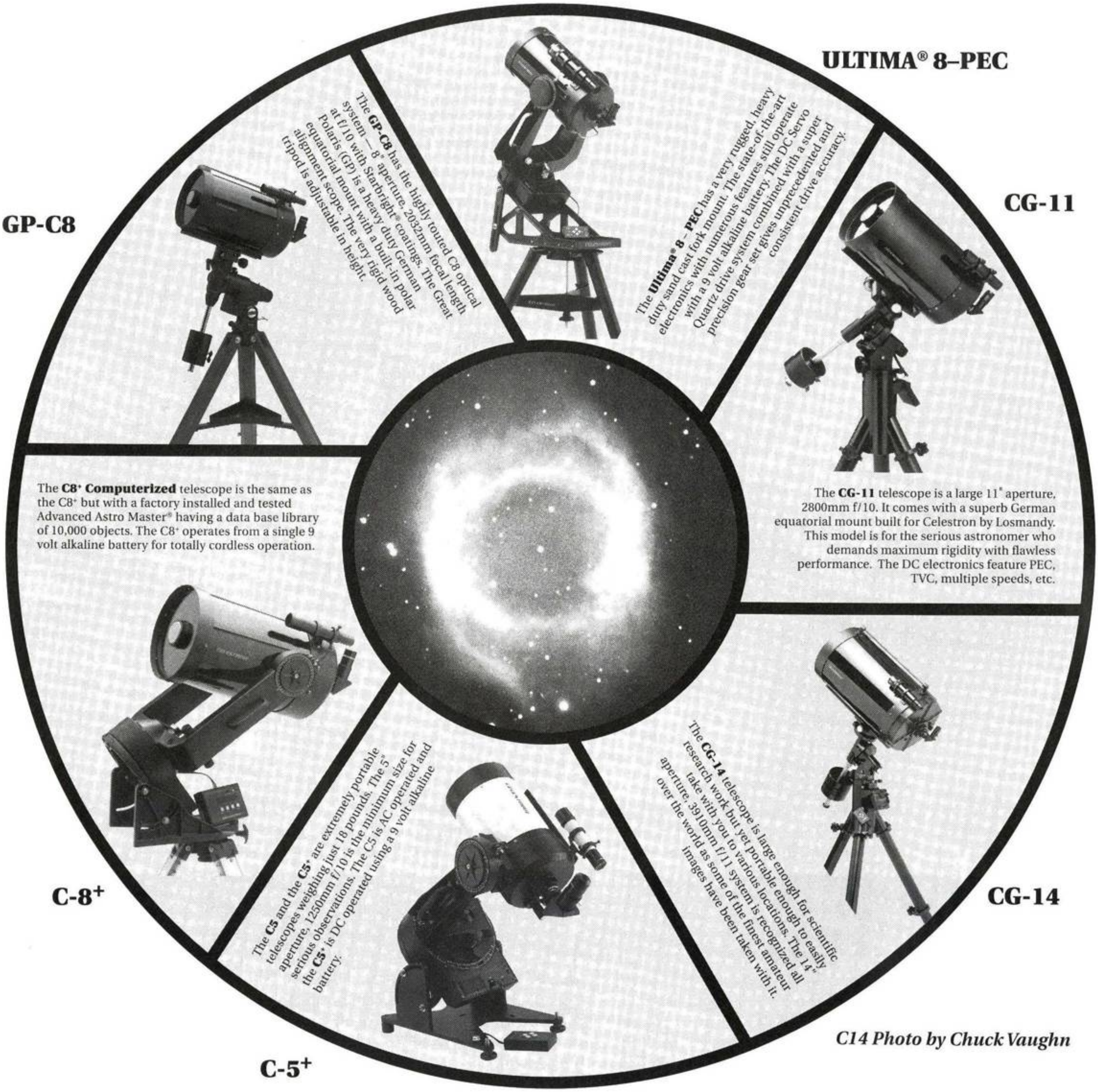
Admittedly, one new theory seriously challenged this tantalizing picture. At the 1955 meeting of the American Astronomical Society, it was suggested that differences between old and new Martian maps were the result of volcanism. Two features thought to have been formed by volcanic fallout were the funnel-shaped bays near Sinus Sabaeus and the Thoth-Nepenthes canal. Ley and von Braun, preferring a lusher Mars, reject this theory on the grounds that it does not account for the majority of dark areas or for their obvious seasonal changes in color.

But time was running out. Less than a decade later the view of Mars as a harsh but not inhospitable world of rolling deserts and exotic vegetation had become, like the Mars of Percival Lowell, part of the Red Planet's historical mystique. In the decades since Mariner 4, a new Mars has taken shape. Today's Mars is a far more hostile place — a bleak world of towering shield volcanos, vast interconnected canyons, huge impact basins, and global dust storms that rage for months at a time.

This year Russia will launch the first spacecraft since Viking designed to place sophisticated instruments on the Martian surface. If all goes well, the mission promises to answer many of the questions astronomers still have about our neighbor in space. So while the fabled Mars of the 1950s no longer exists, it's likely the planet will again be reshaped in new and unexpected ways by the Russian mission and by follow-up missions already on the drawing board. □

A frequent contributor to ASTRONOMY, *Edmund A. Fortier is a high school teacher living in North Scituate, Massachusetts.*

CELESTRON



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The **Ultima® 8 – PEC** has a very rugged, heavy duty sand cast fork mount. The state-of-the-art electronics with numerous features still operate with a 9 volt alkaline battery. The DC Servo Quartz drive system combined with a super precision gear set gives unprecedented and consistent drive accuracy.

GP-C8

The **GP-C8** has the highly touted C8 optical system — 8" aperture, 2032mm focal length at f/10 with Starbright® coatings. The Great Polaris (GP) is a heavy duty German equatorial mount with a built-in polar alignment scope. The very rigid wood tripod is adjustable in height.

CG-11

The **CG-11** telescope is a large 11" aperture, 2800mm f/10. It comes with a superb German equatorial mount built for Celestron by Losmandy. This model is for the serious astronomer who demands maximum rigidity with flawless performance. The DC electronics feature PEC, TVC, multiple speeds, etc.

C-8$^+$

The **C8$^+$ Computerized** telescope is the same as the C8$^+$ but with a factory installed and tested Advanced Astro Master® having a data base library of 10,000 objects. The C8$^+$ operates from a single 9 volt alkaline battery for totally cordless operation.

C-5$^+$

The **C5** and the **C5$^+$** are extremely portable telescopes weighing just 18 pounds. The 5" aperture, 1250mm f/10 is the minimum size for serious observations. The C5 is AC operated and the **C5$^+$** is DC operated using a 9 volt alkaline battery.

CG-14

The **CG-14** telescope is large enough for scientific research work but yet portable enough to easily take with you to various locations. The 14" aperture, 3910mm f/11 system is recognized all over the world as some of the finest amateur images have been taken with it.

C14 Photo by Chuck Vaughn

Celestron offers the discriminating buyer a variety of U.S.A. made Schmidt-Cassegrain telescopes to choose from to satisfy individual preferences in style, aperture and features. Purchasing a Celestron translates into pride of ownership and satisfaction of knowing you have obtained the ultimate in optical precision and mechanical execution. A Celestron telescope will become a complete entertainment center for you, your family and friends.

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ULTIMA EYEPIECES–1¼". Celestron's top of the line eyepieces which use a hybrid design of 4 to 7 elements. Features long eye relief and a wide field. **Full** multi-coating on each air-to-glass surface enhances contrast levels. Computer designed to keep the following aberrations to an absolute minimum: spherical, coma, astigmatism, distortion, color, field curvature and spherical of the exit pupil. Inside and all lens edges are blackened to keep out reflected light. The outside is flat black with rubber grips. Included are rubber eyecups for comfort and to keep out extraneous light. Threaded barrels accept thread-in filters. Lens and barrel caps included. Better than any Plössl!

Ultima Eyepieces

FOCAL LENGTH	EYE RELIEF	APPARENT FIELD
5mm	4mm	50°
7.5mm	5mm	51°
12.5mm	9mm	51°
18mm	13mm	51°
24mm	18mm	51°
30mm	21mm	50°
35mm	25mm	49°
42mm	32mm	36°

ZOOM EYEPIECE – A deluxe zoom eyepiece 6.5 to 18mm - 1.25" was recently designed and has become the finest zoom ever offered for medium to high powered observing. This eyepiece is multi-coated and extremely lightweight (5 oz.).

Deluxe Zoom Eyepiece - 1.25"

1¼" Plössl Eyepieces

PLÖSSL EYEPIECES – Plössl quality eyepieces (the market's best value) are now available at affordable prices. All units are **multi-coated** for enhanced contrast. A complete series of **both .96"** and **1¼"** sizes are offered. Celestron is the first to offer .96" eyepieces of superior design.

FOCAL LENGTH	APPARENT FIELD	EYE RELIEF	SIZES
6.3mm	52°	5mm	1¼"
7.5mm	52°	5mm	.96", 1¼"
10mm	52°	6.5mm	.96", 1¼"
12.5mm	52°	8mm	1¼"
17mm	52°	13mm	.96", 1¼"
26mm	50°	22mm	.96", 1¼"
32mm	52°	22mm	1¼"
40mm	46°	31mm	1¼"

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LV EYEPIECES – A new generation of eyepieces using the rare earth glass – lanthanum. All focal lengths have a **20mm eye relief!** Optics are all **fully multi-coated.** The results are excellent and high power viewing is more relaxed.

FOCAL LENGTH	BARREL DIA.	APPARENT FIELD
2.5mm	1¼"	45°
4mm	1¼"	45°
5mm	1¼"	45°
6mm	1¼"	45°
9mm	1¼"	50°
10mm	1¼"	50°
15mm	1¼"	50°
20mm	1¼"	50°
25mm	1¼"	50°
30mm	2"	50°

Ultima Barlow Lens

BARLOW LENSES –THE BEST! Celestron offers an assortment of Barlow Lenses that will double the magnifying power of your oculars by increasing their effective focal length.

Barlow Lenses mount into your telescope's Visual Back, focuser or star diagonal. The new premium quality achromatic Barlow Lenses (1.25" and .96") are **fully** multi-coated and of the short design (under 3"). The .96" weighs just 2 oz. and the 1.25" weighs 4 oz.! The clear aperture is 27mm on the 1.25" model and 21mm on the .96" unit.

The Ultima Series Barlow (2X - 1.25") is an air-spaced, three-element apochromatic design with a 27mm clear aperture. It is a super high quality design and **fully** multi-coated. It is amazingly short (2.75") and weighs just 5 oz. ***The ultimate in Barlow Lenses.***

1.25" Eyepiece Filters

EYEPIECE FILTERS – These filters are an invaluable aid to lunar and planetary observers. They reduce glare and light scattering, increase contrast by selective filtration, increase definition and resolution, reduce irradiation and lessen eye fatigue.

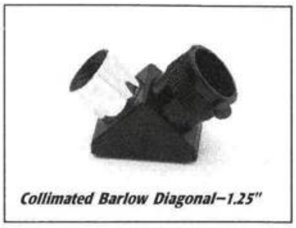
Celestron offers the most complete line of eyepiece filters in the industry but more importantly – the finest quality filters.

Celestron filters offer 18mm clear aperture for the .96" size and a full 26mm clear aperture in the 1.25" size. The filters utilize quality, solid plane parallel glass with excellent homogeneity. The filters are anti-reflection coated on **both sides** of the glass to prevent glare and ghosting.

The filters are mounted in black anodized aluminum cells with the Kodak Wratten Series engraved each one and they are supplied in a plastic case.

Featured in this ad are a few of the accessories offered by Celestron. For a more complete listing, ask for the **New Accessory Catalog.**

COLLIMATED BARLOW DIAGONAL – 1.25". An ultra compact 90° barlow diagonal. It contains an integral 1.7X large aperture multi-coated achromatic Barlow lens. The diagonal is laser aligned (collimated) for rotating centration. Ideal for visual centering of CCD objects and critical setting circle use.


Collimated Barlow Diagonal–1.25"

DIGITAL SETTING CIRCLES – ADVANCED ASTRO MASTER. Computerize your telescope! This pointing system contains a data base of over 10,000 objects. Once aligned, it will guide you to any one of these objects. Included are the entire RNGC catalog, the Messier catalog, IC catalog (selected objects), major planets, over 241 interesting double and multiple stars and a user definable catalog of 25 objects!

Advanced Astro Master

Use with or without an equatorial mount. No need to polar align or enter longitude or time. Scrolling description of each object, directs you from object to object; immediate alignment on currently viewed object. The 16 character LED readout provides: object coordinates, magnitude, type, common name, constellation and additional description. Operates on a standard 9V battery. Weighs 6 oz. Very easy to install.

The newest versions contain an RS-232 serial interface to enable usage from PC programs.

VIBRATION SUPPRESSION PADS. Reduce telescope vibration caused by windy conditions, an unsteady mount or an accidental bump. These three pads reduce the vibration time by almost 100% and also the vibration amplitude. The pads fit between the bottom of the tripod legs and the ground. They work on any surface: grass, dirt, concrete, asphalt, wood, etc. The VSP work well with telescopes and spotting scopes to greatly improve stability.

VSP

Tripod - Alt-Az Photo Mount

TRIPOD – ALT-AZ PHOTO MOUNT. This tripod mount serves as a super heavy duty photo tripod for cameras with large telephoto lenses, spotting scopes or binoculars. This unit can also be used for small telescope owners who want to upgrade their mounts. It comes with two slow motion cables, adjustable wood tripod and with a ¼ x 20 photo head.

REDUCER/CORRECTOR f/6.3 – This combination focal reducer and field corrector lens accessory works with all Celestron SC's. Now it is possible to have a dual focal ratio instrument without sacrificing image quality. The Reducer/Corrector is f/6.3 for C5, C8, C9¨, and C11, f/7 for C14. The drawbacks of a dedicated f/6.3 Schmidt-Cassegrain with its much larger central obstruction (causing reduction of contrast) and the inability to utilize longer focal ratios for certain objects led us to design this four element, fully multi-coated accessory. Results are amazing BOTH visually and photographically. ***Far superior to competitive units!***

Reducer/Corrector f/6.3

Flashlight, LED

FLASHLIGHT – A flashlight with a **red LED** for star map reading and night use at the telescope. The LED does not impair night vision. Also great for bird watchers to study field guides in low light conditions without disturbing the birds. Compact at only 6" long and weighs just 2.5 oz. Two AA batteries are included.

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EPSILON ERIDANI:
THE ONCE & FUTURE SUN

As a young solar-type star near Earth, Epsilon Eridani offers a window on the Sun's past — and a possible future abode for intelligent life.

by Ken Croswell

Just to the west of Orion the Hunter in the evening sky lies an inconspicuous 4th-magnitude star in the ancient constellation of Eridanus the River. Designated Epsilon, this star is visible to the naked eye, although it is so dim that few observers would give it more than a passing glance.

Despite its obscurity, this star has attracted the attention of astronomers, for its importance far outshines its modest visual appearance. The reason: At a distance of 10.7 light-years, it is the closest single solar-type star to the Sun.

In 1960 these qualities sparked the interest of a young radio astronomer named Frank Drake. That year Drake chose Tau Ceti and Epsilon Eridani as the two target stars for Project Ozma, the first search for radio signals from extraterrestrial intelligent life. Tau Ceti, another nearby solar-type star, proved quiet. But it was a completely different story when Drake swung the telescope toward his second star.

Almost as soon as he began observing Epsilon Eridani he detected a peculiar signal pulsing at eight times a second. Mysteriously, the signal quickly vanished, as if the star's inhabitants knew he was on to them, and the star remained silent for days afterward. Finally, about ten days later, the strange signal returned. This time, though, Drake's team noticed with disappointment that the signal was terrestrial, emanating from an airplane flying high overhead.

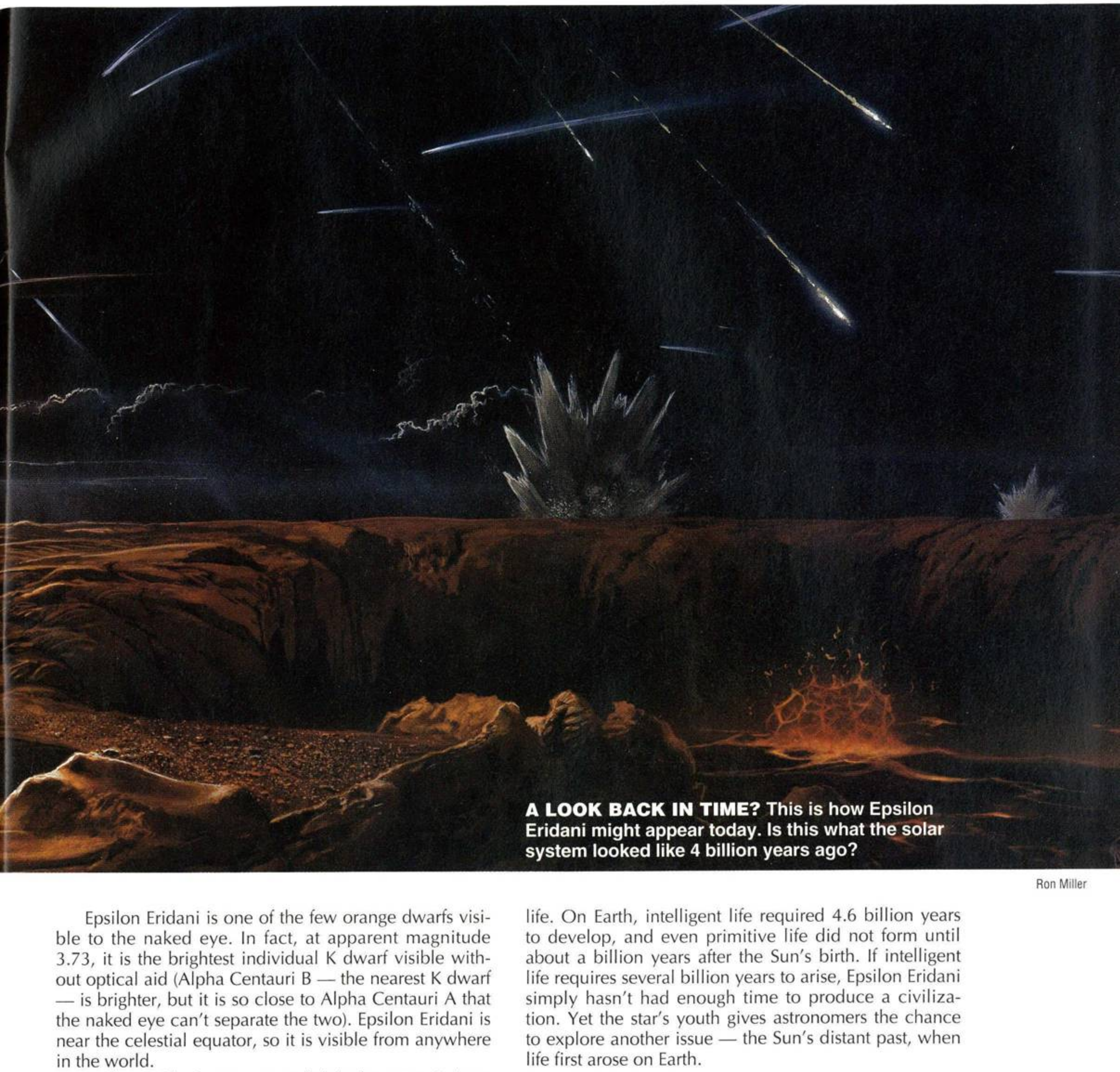
Since 1960 astronomers have learned that despite its Sun-like nature, Epsilon Eridani is unlikely to support intelligent life. The star is less than one billion years old, so any life there simply has not had enough time to develop intelligence. Yet the star's very youth gives astronomers an opportunity to explore the Sun's distant past, when life was struggling to establish a foothold on Earth. Most nearby solar-type stars, such as Alpha Centauri and Tau Ceti, are much older than Epsilon Eridani, and some are older than the Sun. But because Epsilon Eridani is so young, astronomers observe it to study the Sun as it was 4 billion years ago.

A Cool Sun

Epsilon Eridani is an orange dwarf of spectral type K, with a surface temperature of 5200 kelvins (8900° F). The star is therefore slightly cooler than the G-type Sun, which is yellow and has a temperature of 5800 K. Epsilon Eridani is also fainter, emitting only 30 percent as much visible light as the Sun. The star's lower temperature and luminosity stem from its mass, which is 80 percent that of the Sun. Both the Sun and Epsilon Eridani lie on the main sequence, which means their cores generate energy by converting hydrogen into helium. Because of Epsilon Eridani's lower mass, however, its fusion reactor runs more slowly than the Sun's, accounting for the star's lower temperature and luminosity.

Despite these differences, Epsilon Eridani more closely resembles the Sun than most of our neighbors do. Most stars in the Galaxy are red dwarfs, stars much fainter and cooler than the Sun; 17 of the 28 stars within a dozen light-years of the Sun are red dwarfs.

Orange K-type dwarfs such as Epsilon Eridani make up about 15 percent of all stars in the Galaxy. But unlike Epsilon Eridani, few of these stars are visible to the naked eye. Although K-type stars abound in the night sky, nearly all are giants like Arcturus and Aldebaran rather than dwarfs like Epsilon Eridani. K-type giants are actually much rarer than K-type dwarfs, but the greater luminosity of the giants means that they far outnumber the dwarfs among the stars you can easily see.



A LOOK BACK IN TIME? This is how Epsilon Eridani might appear today. Is this what the solar system looked like 4 billion years ago?

Ron Miller

Epsilon Eridani is one of the few orange dwarfs visible to the naked eye. In fact, at apparent magnitude 3.73, it is the brightest individual K dwarf visible without optical aid (Alpha Centauri B — the nearest K dwarf — is brighter, but it is so close to Alpha Centauri A that the naked eye can't separate the two). Epsilon Eridani is near the celestial equator, so it is visible from anywhere in the world.

Epsilon Eridani appears so bright because it is so close. Only eight star systems are closer to the Sun. Among star systems visible to the naked eye, Epsilon Eridani is the third nearest the Sun; only Alpha Centauri (4.3 light-years away) and Sirius (8.6 light-years away) lie closer.

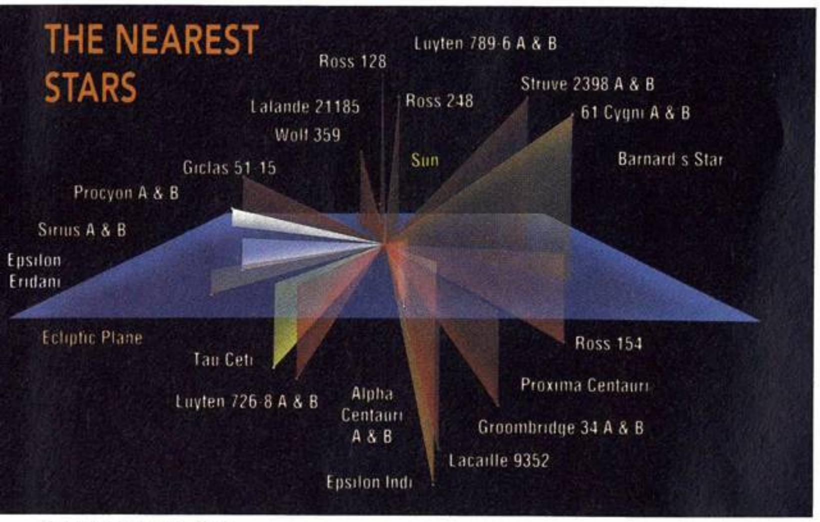
Like the Sun, Epsilon Eridani is a single star. Astronomers believe that single stars offer the best chances for having planets. In a multiple star system like Alpha Centauri, the gravity of one star may disturb planets developing around another, so that planets never form around any of them. Because Epsilon Eridani is single, it could easily have planets.

Planets, of course, are a prerequisite for intelligent life. On Earth, intelligent life required 4.6 billion years to develop, and even primitive life did not form until about a billion years after the Sun's birth. If intelligent life requires several billion years to arise, Epsilon Eridani simply hasn't had enough time to produce a civilization. Yet the star's youth gives astronomers the chance to explore another issue — the Sun's distant past, when life first arose on Earth.

The Youth of Epsilon Eridani

Both newborn stars and dying giant stars give clear indications of their age. But determining the age of a star that plods inconspicuously along the main sequence for billions of years is more challenging. The first evidence of Epsilon Eridani's youth was the star's strong emission in the violet part of its spectrum, at wavelengths produced by singly ionized calcium (3934 and 3968 angstroms). The Sun's strongest emission at these wavelengths arises from areas of magnetic activity surrounding sunspots. Epsilon Eridani has a stronger calcium emission, which signals the presence of a magnetic field far more powerful than the Sun's. Solar-type stars derive their magnetic fields from rotation: The faster they rotate, the stronger their field. Thus, Epsilon Eridani's strong magnetic field suggests that the star spins faster than the Sun.

This, in turn, means the star is young, because single solar-type stars spin more slowly as they age. Such stars discharge a stream of particles away from themselves — the so-called stellar wind — which causes them to rotate more slowly, just as spinning ice skaters extend their arms to slow down their rotation. Because it is single and fast-spinning, Epsilon Eridani is probably less than a billion years old.



ASTRONOMY, Thomas L. Hunt

During the 1980s, astronomers verified that Epsilon Eridani spins faster than the Sun. They confirmed this by noticing that its emission at certain wavelengths, including those of calcium, varies every 11.1 days. This must be the star's rotation period. In contrast, the middle-aged Sun takes about a month to spin once.

Because sunspots and solar flares arise from powerful magnetic field concentrations, Epsilon Eridani's strong magnetic field almost certainly produces starspots that darken a large portion of the surface, and huge flares must spew into space that dwarf those on the Sun.

Both spots and flares can alter a star's brightness. In 1991, Douglas Hall of Vanderbilt University in Nashville, Tennessee, and a network of six amateur astronomers he organized, reported that Epsilon Eridani is indeed variable. It fluctuates by 0.01 to 0.03 magnitude with a period that matches the 11.1-day rotation. This variability probably arises from starspots, but these spots are much larger than those on the Sun. Epsilon Eridani's starspots are 5 to 10 times the diameter of Earth, whereas typical spots on the Sun are one Earth-diameter across.

In 1995, David Gray of the University of Western Ontario in London, and Sallie Baliunas of the Harvard-Smithsonian Center for Astrophysics reported that Epsilon Eridani may have a starspot cycle, during which the number of spots waxes and wanes. If the cycle exists, it appears to be 5 years long, about half of the Sun's 11-year sunspot cycle.

All of these characteristics paint a picture of what the Sun must have been like 4 billion years ago: a fast-spinning star with a powerful magnetic field, bigger sunspots, and enormous flares.

Does Epsilon Eridani Have Planets?

Epsilon Eridani may offer us more than a snapshot of the young Sun, however; it may also help reveal how Earth and the other planets formed and evolved. Astronomers believe the planets arose from a large disk of gas and dust that surrounded the Sun at birth. This material coalesced to form small rocky bodies that in turn collided and stuck together, creating the terrestrial planets and the cores of the outer planets. Asteroids and comets crashed into the newborn planets, which grew larger and larger until they assumed their present sizes. Most of this so-called heavy bombardment occurred during the first 700 or 800 million years of the Sun's life. Many of the craters on Mercury, the Moon, Mars, and the satellites of the outer planets date back to this ancient era.

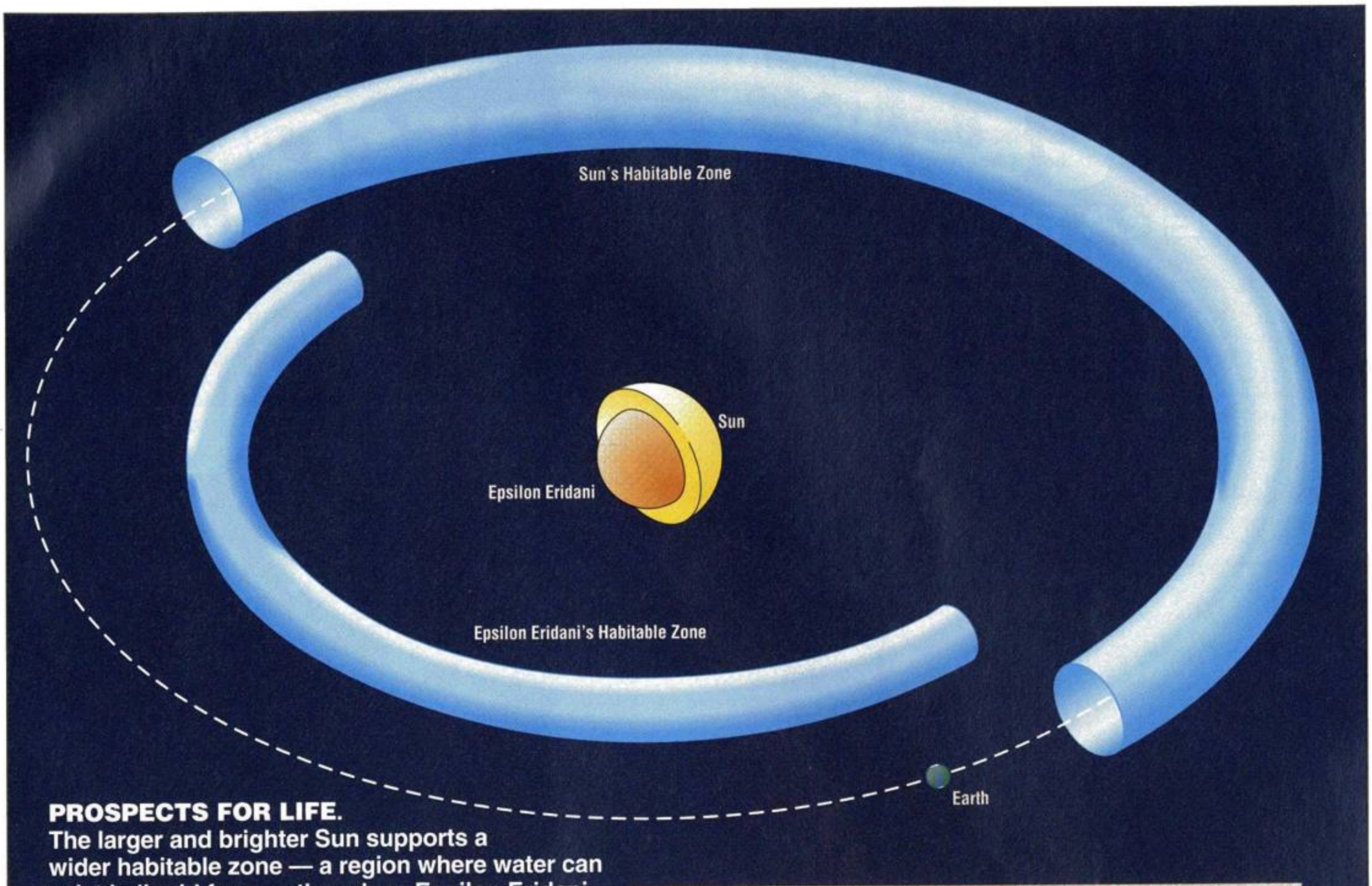
Could the same process now be happening around Epsilon Eridani? At this very moment asteroids and comets may be flying through an Epsilon Eridani solar system, smashing into newly formed planets and satellites. Comets may be delivering a vital ingredient for life — water — to an inner planet, setting the stage for a world like our own.

Of course, there is no observational evidence that Epsilon Eridani formed planets the way the Sun did, or even that it formed planets at all. Furthermore, Epsilon Eridani is not a carbon copy of the Sun: It is fainter, cooler, and less massive. These differences may affect the formation of a planetary system in ways we don't yet understand.

In addition, Epsilon Eridani has a lower metallicity than the Sun. A star's metallicity is its abundance of elements heavier than helium — vital planet-forming (and life-forming) ingredients such as carbon, nitrogen, oxygen, and iron. Epsilon Eridani's metallicity is only 80 percent that of the Sun. The star therefore has somewhat fewer of the basic ingredients it needs to form planets. Nevertheless, the star's metallicity is probably sufficiently high that planets can form.

In fact, astronomers have found evidence that Epsilon Eridani has the makings of a planetary system. In 1983, the Infrared Astronomical Satellite (IRAS) detected excess infrared radiation from several nearby stars. Many of these were hot white stars of spectral type A, such as Vega and Fomalhaut. But IRAS also detected an infrared excess from Epsilon Eridani. This excess infrared radiation probably arises not from the stars themselves but from an orbiting disk of dust. Epsilon Eridani's light heats the dust, which in turn radiates the heat in the infrared part of the spectrum. A dusty disk is a long way from a full-fledged solar system, of course, but the IRAS results do suggest that something circles Epsilon Eridani.

If planets do orbit Epsilon Eridani, one of the small inner worlds could resemble ancient Earth, before or shortly after life arose. Because Epsilon Eridani is fainter and cooler than the Sun, this planet would have to lie closer to Epsilon Eridani than Earth does to the Sun in order to receive enough warmth. It would probably lie a little closer than Venus' distance from the Sun. Such a planet could have just the right temperature for liquid water and the development of life.



PROSPECTS FOR LIFE.
The larger and brighter Sun supports a wider habitable zone — a region where water can exist in liquid form — than does Epsilon Eridani.

ASTRONOMY, Steven Davis

EPSILON ERIDANI AND THE SUN

	Epsilon Eridani	**Sun**
Relative Brightness	0.30	1.00
Spectral Type	K2	G2
Color	Orange	Yellow
Temperature	5200 K	5800 K
Relative Mass	0.8	1.0
Relative Radius	0.7	1.0
Rotation Period	11.1 days	One month
Relative Metallicity	0.8	1.0

A Bright Future

What does the future hold for Epsilon Eridani? If the star has planets, they will sweep up most of the remaining asteroids and comets now racing through its solar system. Furthermore, the star will gradually brighten, because main-sequence stars get brighter as they age. For example, the Sun is 40 percent brighter now than it was when it first reached the main sequence. Even as Epsilon Eridani brightens, though, it will remain fainter than the Sun.

Meanwhile, one of the star's inner planets may already have oceans of liquid water, and primitive life may someday thrive in these seas. This primitive life may later evolve into more complex life. Over billions of years, this more complex life may evolve into intelligent life.

Of course, no one yet knows what is happening around Epsilon Eridani. Even under ideal conditions — a good solar-type star and a good Earth-like planet — we do not know how readily primitive life develops, let alone how frequently it evolves into advanced life and then intelligent life. Moreover, we don't know how Epsilon Eridani's cooler temperature and lower metallicity affects its ability to support life.

Nevertheless, 3 or 4 billion years from now, as Epsilon Eridani and its planets mature, intelligent life may arise on a world like Earth. At that time, our own Sun will show signs of its advanced age: Although it will still be a yellow star, it will be so bright that Earth's oceans will have boiled away and frigid Mars will be getting warmer.

Long before then, however, our descendants will have begun to voyage to the stars. Just as it was for astronomers who searched for extraterrestrial intelligence, Epsilon Eridani will surely be one of our first targets — a star that gives insight into the Sun's past, the birth of its planets, and possibly the conditions that led to life here on Earth. ☐

Ken Croswell earned his Ph.D. in astronomy from Harvard University and is author of The Alchemy of the Heavens *(Doubleday/Anchor, 1995), whose final chapter discusses the likelihood of intelligent life around nearby stars like Epsilon Eridani. His previous article, "A Milestone in Fornax," appeared in October 1995.*

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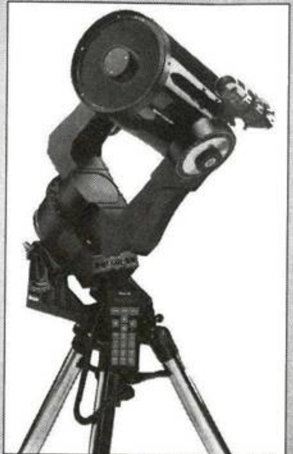

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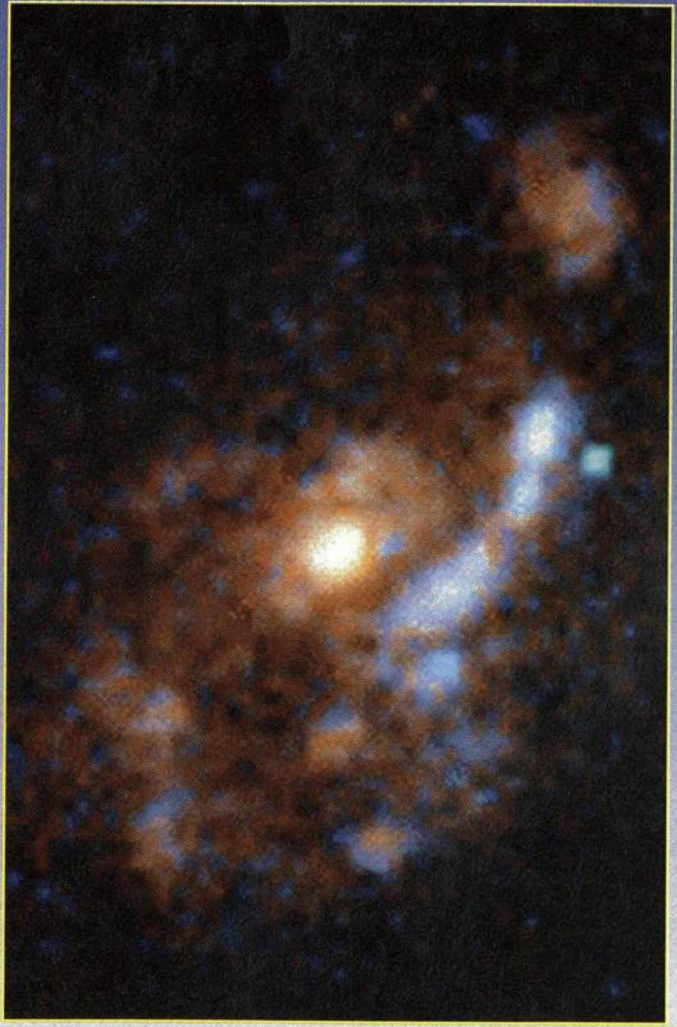
Our Strange, Scrappy Ancestors

Hubble's sharp eye produces a record-setting image that reveals a new class of distant, chaotic galaxies.

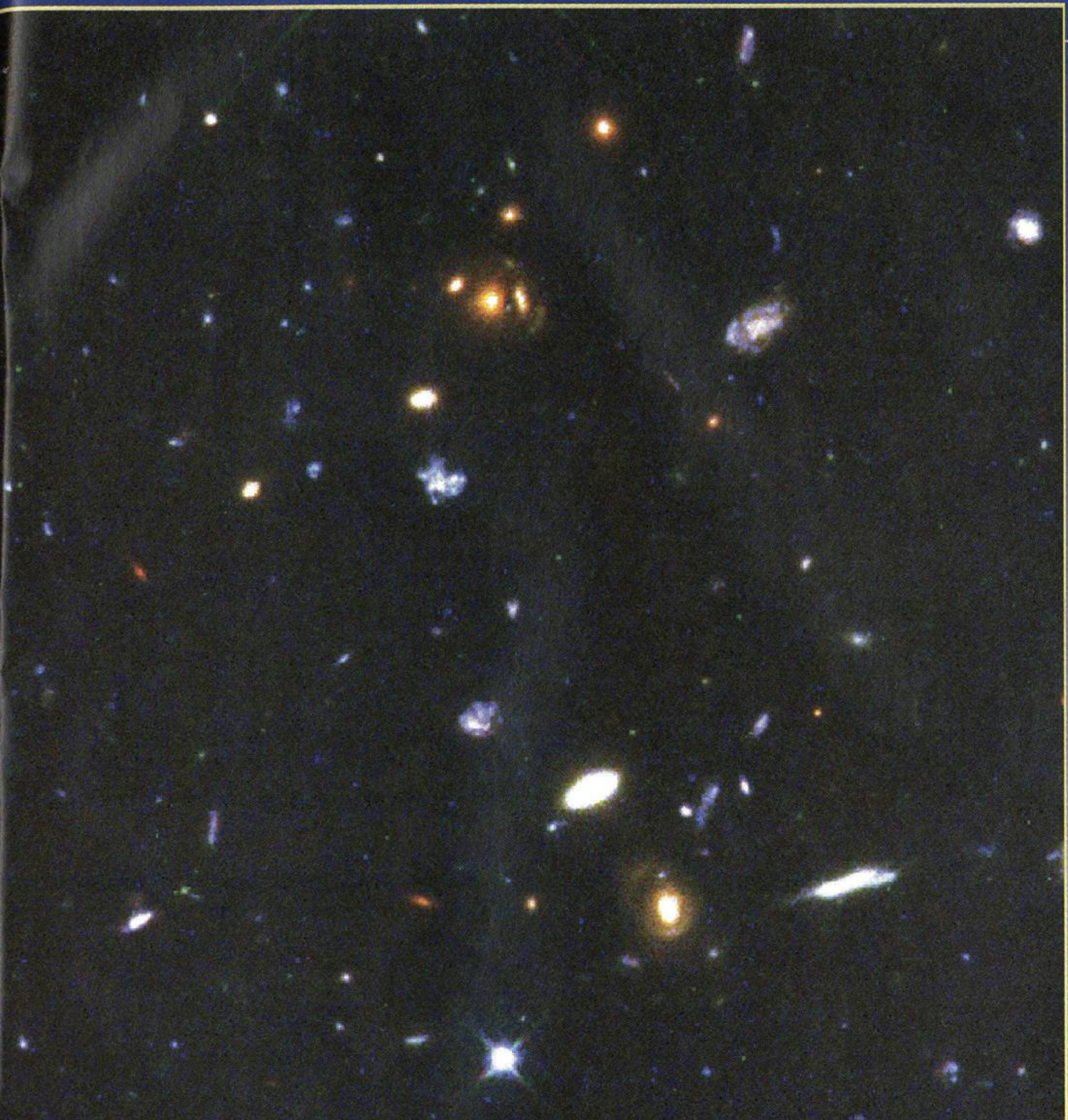
by David J. Eicher



Richard Griffiths/Johns Hopkins, NASA

An extremely long exposure made during the last week of July, 1995, with the Hubble Space Telescope shows a population of faint blue galaxies that are the most abundant type of galaxy in the universe. The distances to these unusual blue objects range from three to eight billion light-years, meaning they were abundant when the universe was a fraction of its current age. The faint blue galaxies have apparently dissipated or self-destructed by now, and so they do not show up in the nearby universe.

Hubble's superb resolution shows that these galaxies form a distinct class and do not resemble the elliptical or spiral galaxies found in the modern universe. Instead, they have a wide variety of fragmentary shapes suggesting that galaxy collisions and interactions were more common in the past. The galaxies' blue color results from intense bursts of star formation, which produce



Rogier Windhorst and Simon Driver/Arizona State University, Bill Keel/University of Alabama, and NASA

young, hot, blue stars.

The picture covers an area of sky in Hercules only 1/10th the diameter of the Moon, and shows objects as small as 0.06 arcsecond and as faint as 30th magnitude. The image is a true-color composite made from exposures taken in red, green, and blue light with Hubble's Wide Field and Planetary Camera 2. It required a total of 48 orbits of the telescope around Earth, amounting to roughly one day of exposure time, to record the faintest objects in the image, which are about one billion times fainter than the faintest visible with the naked eye.

The smaller photos depict a number of galaxies with peculiar and irregular shapes. They are not from the same field in Hercules. They do show similar objects, however, and were recorded as part of an ongoing study called the Medium Deep Survey that will catalog such distant galaxies. Discerning structure in these galaxies, including the blue regions of star formation, is a major victory for Hubble: Previous images from groundbased telescopes revealed only fuzzy blobs. □

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USE THIS ONE TO SEE NGC 281 ↗

FILTER OF THE MONTH: The LUMICON UHC Filter will help you see the large nebula NGC 281 1.5° east of Alpha Cassiopeia.

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"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain."
***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

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"Consistently performed well on all emssion and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

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"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

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*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

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Universal adapter for 1¼'' filters. Adapts the 1¼'' filters to any 1¼'' eyepiece	$19.50
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**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

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LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

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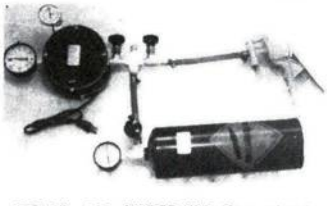
MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**



MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

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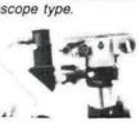
All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™



Full aperture. Installs in seconds. Specify 2'' or 1¼''.

NEWTONIAN EASY-GUIDER	**$189.50**
48mm Coma corrector/field flattener	**$285**
3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$409,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

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Adapter for Hasselblad **$225,** Mamiya 645 **$98**
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For Celestron-11, C-14, and the 10'' Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

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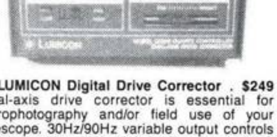
WHAT DO YOU NEED?

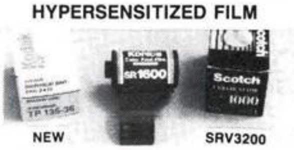
1. Illuminated reticle eyepiece **$109.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**



3. **LUMICON Digital Drive Corrector . $249**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 30Hz/90Hz variable output controls telescope drive. 60Hz digital reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Dec. reverse switch for Newtonians.
Declination motor (state telescope) ... **$109**
Variable dec. speed drive w/built-in 5AH battery **$299**

HYPERSENSITIZED FILM



YES! WE STILL HAVE FUJI HG400!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$14.95**
Kodak Ektar 1000 fast, fine grain	24	**$12.95**
Fuji HG400 fine grain color neg.	12	**$14.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

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LED FLASHLIGHT . $14.95

LUMICON LUMILITE™ Red LED Flashlight

This red LED flashlight preserves night vision. It uses 2 AA cells (included!) which last 60-100 hours.

LUMILITE red LED flashlight **$14.95**

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LUMICON UNITRAK DRIVE CORRECTOR

Operate your telescopes ***anywhere!*** Use the single-axis Unitrak with a 12V DC car battery. The dual-axis drives are for photography and use either 12V DC or 125V AC.

Unitrak™ single-axis corrector	**$99.95**
LUMICON DX200 dual-axis correc.	**$249.00**
DX2BP incl. battery & charger ...	**$298.00**

Convenient rechargeable Porta-Pac battery:

12V DC Porta-Pac (5AH) & recharger	**$79.50**
12V DC Porta-Pac (12AH) & recharger	**$99.50**

48MM COLORED FILTERS

FOR EVERY NEED

Select 48mm UV, Red, Yellow, Green (ea.)	**$19.95**
48mm Cyan (absorbs red)	**$69.00**
48mm High Performance Blue (95% T)	**$49.00**
48mm Tri-Color Blue (80% T- 400nm) .	**$49.00**
48mm Ultraviolet (85% T- 370nm)	**$49.00**
Color Separation Set: cyan, red, yellow, blue	**$149**

RICH FIELD! 2° in 8" SCT

NOW ONLY

$99.50

LUMICON Rich-Field Viewer on C-8 with LUMICON 2" star diagonal and 2" eyepiece.

The LUMICON Rich-Field Viewer fits **all** commercial Schmidt-Cassegrain telescopes. It has a high-performance coated achromatic focal reducing lens with 50mm or 80mm clear aperture for **totally unvignetted viewing** with 2" or 1¼" eyepieces. It is available in several combinations depending on the eyepiece and field-of-view you desire (see chart below).

LUMICON Rich-Field Viewer	**$99.50**
Giant Rich-Field Viewer (10-14") ..	**$250.00**

Optional Eyepiece	TRUE FIELD	Price
Meade 32mm Plossl	1.4°	**add $99**
Meade 32mm 2" Wide-Field†	1.9°	**add $439**
Meade 40mm 2" Wide-Field†	2.4°	**add $498**

†Includes 2" enhanced aluminum Star Diagonal (may not reach focus on some telescopes).

PROTECTIVE DUST COVERS

Protect your valuable telescope optics, eyepieces and accessories with these black vinyl covers. Add $1 shipping. Deduct 10%, 2 or more sets.

1¼" O.D. plug, seals focuser	**4/$2**		
2" O.D. plug	**2/$2**	3½" O.D. plug	**$1.50**
1¼", 1⅜" ...	**3/$2**	7½"	**$10**
1½"	**2/$2**	9½", 10.4"*	**$15**
2"	**2/$2**	12½", 12⅞"* ...	**$20**
2⅛"	**2/$20**	15.6", 16"*	**$28**
5½"	**$6**	19" (DS-16)	**$35**
*Fits Odyssey		21" (Odyssey-II)	**$35**

MEADE 8" - 16" LX200
NEW! 8" - 10" LX50

16" LX200 $14,950

8" LX100
$1950

Meade 8" LX200 Telescopes

LX100 - includes wedge, best for photography.
LX200 - full computer control w/64K obj. mem.
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your Schmidt-Cassegrain.

8" **LX100** with wedge ($105 P&S)	**$1950**
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Wedge for photographing w/8" LX200 ..	**$139**
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12" **LX200** (f/10 only)($215 P&S)	**$3995**
Super Wedge for photogr. w/10",12" LX200	**$395**
16" **LX200** f/10 w/tripod ($385 P&S) .	**$14,950**
Dew Shields: 8" .... **$119;** 10"	**$129**
12" .... **$189;** 16"	**$289**

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Meade 2045D 4" f/10 w/motor ($40 P&S)	**$699**
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Model 2120B 10" w/wedge, tripod .	**$1599**
10" **LX50** w/wedge, tripod ($145 P&S)	**$1795**

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4", 8", f/6 or f/10	**$249**
Giant EASY-GUIDER for 10"/12" f/4-f/10 .	**$395**

MEADE STARFINDERS

8" f/6
$699*

New 8" f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive (equat. only), mount, finderscope and 25mm (=48X) eyepiece.

6" **f/8 Dobsonian Starfinder** ($46 P&S)	**$325**
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8" **f/6 Dobsonian Starfinder** (add $59 P&S)	**$425**
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10" **f/4.5 Equat. Starfinder 10** (add $99 P&S)	**$799**
12.5" **f/4.8 Dobsonian Starfinder** ($95 P&S)	**$795**
16" **f/4.5 Starfinder 16** (ship. freight COD) .	**$2495**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $99 higher.

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LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector .	**$99**
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Meade 47M Dual-axis drive corrector with tangent arm & electric declination ..	**$475**
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LUMICON® SKY VECTOR™

Higher Performance — Lower Price

LUMICON ACCESSORIES

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LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
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- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

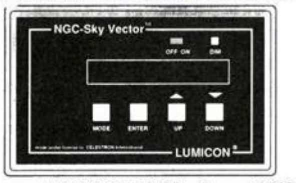
NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

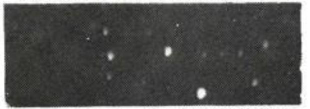


Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR



Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2" EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8".

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER .	**$189.50**
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2" Adapter for Pentax 6X7 ...	**$129.00**
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2" DELUXE BARLOW

1.8x Multiplier Lens (2" Barlow)

LUMICON 1.8x Multiplier Lens (2" Barlow) **$259.00**

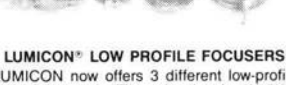
LARGE UV/DUST SEAL

Protect the optics of your 8-14" Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080 ...	**$119.50**
UV/Dust Deal for Celestron C-8 ...	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14 .	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50



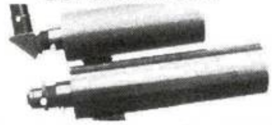
LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	**$69.50**
LUMICON 2" Helical Focuser 1½" high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2" Astro Systems focuser, only 2" high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2"/1¼" **adapter** w/48mm filter threads	**$20.00**
2" LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™



Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼" 50mm Finderscope **$69.50**, right-angle	**$69.50**
1¼" straight-thru 80mm SUPER-FINDER .	**$189.50**
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25mm Cross-hair 1¼" eyepiece (12X)	**$49.00**
Large mounting rings for 80mm Finder	**$55.00**
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1¼" 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2" adapter for C-8, Meade 2080, etc. ...	**$29.50**
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2" adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2" adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1" long 1¼" OD thread-in extension ...	**12.00**
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3" long extension for 2" eyepieces* ..	**$29.00**
2" long extension for 2" eyepieces* ..	**$29.00**

VIEWING ADAPTERS

2"/1¼" reducing bushing,threaded 48mm*	**$25.00**
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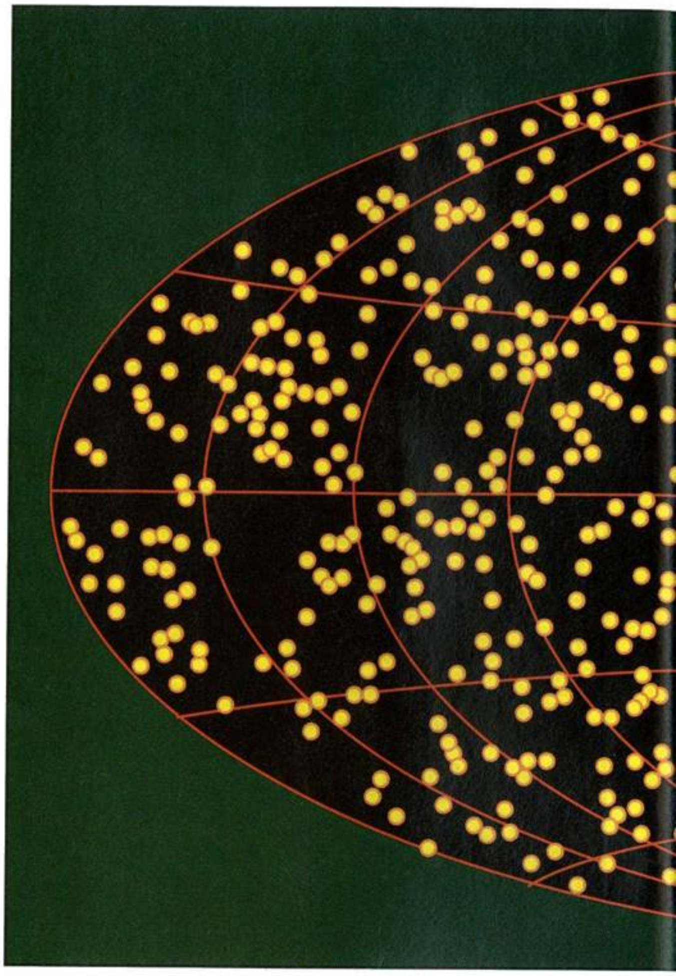
T-thread/1¼" adapter	**$25.00**
F/10 2" or 1¼" eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2" Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

Gamma Ray Bursters: Near or Far?



by Richard Talcott

On July 2, 1967, an intense burst of gamma rays washed over a U.S. military satellite. Was it the telltale signature of a clandestine nuclear weapons test in the atmosphere? Fortunately, no. Astronomers now know that the burst, and the more than a thousand similar bursts detected since, didn't come from Earth but from . . . somewhere else.

The debate over where gamma-ray bursts come from has raged for nearly three decades. If anything, it has grown more heated in the past few years. Some researchers hold that the bursters lie within our own Milky Way Galaxy, while others argue they lie at cosmological distances, in the far reaches of the universe.

This debate stands at the frontier of modern science. It is an attempt to explore the basic nature of an object about which almost nothing is known. Here we present the opposing viewpoints: galactic proponent Don Q. Lamb of the University of Chicago holds court on the left-hand pages of the next three spreads; cosmological proponent Bohdan Paczynski of Princeton University on the right-hand pages.

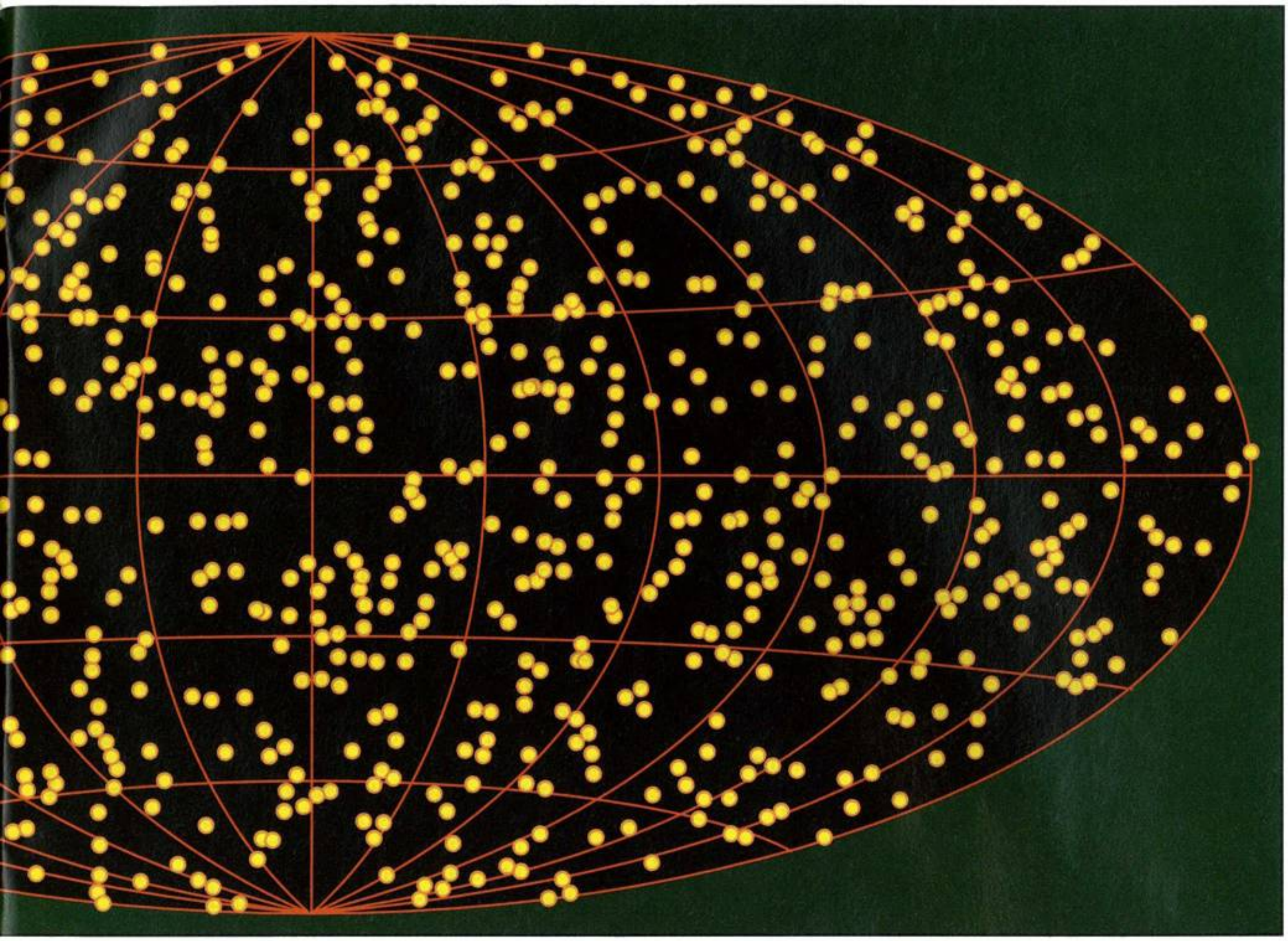
Bursts Originate in our Galaxy

Neutron stars moving at incredible speeds form a distant "corona" surrounding our galaxy that can account for the observed distribution of gamma-ray bursts. In addition, these neutron stars can produce bursts that have the energy, duration, and spectrum of gamma-ray bursts.

Observers and theorists have studied gamma-ray bursts intensely for more than two decades, and yet have been unable to shed much light on them. No one knows for sure what gamma-ray bursts are, where they come from, or even if they all arise from a single phenomenon.

Look at the problems bursts present. They occur at largely random times and come from seemingly random directions. We don't know their precise positions on the sky. Some last for a fraction of a second, others for several minutes. Some have energies a million times greater than others. And no one has been able to find counterparts at other wavelengths.

There is no overwhelming piece of evidence that proves gamma-ray bursts lie in the Galaxy or at cosmological distances. And as so often happens at the frontier of science, the evidence is at best circumstantial and sometimes contradictory. Yet in the scientific process, each piece of evidence must be weighed. Some pieces receive more weight, others less. Different scientists may even give different weights to the same evidence. But by carefully weighing the evidence, eventually scientists reach a conclusion. At this stage in the debate, the evidence clearly leans toward the galactic hypothesis.



Bursts Arise in the Distant Universe

Earth appears to lie at the center of a spherical and bounded distribution of gamma-ray bursters, just what you would expect if they lie at cosmological distances. This is incompatible with any objects known to be in our galaxy.

The most important piece of evidence we have on the distances to gamma-ray bursts is their distribution in space. First, the bursts appear to be distributed isotropically, the same in all directions. Second, there seems to be a shortage of weak bursts in all directions.

This type of distribution matches that of all objects known to be at cosmological distances, like galaxies and quasars, but is inconsistent with the distribution of any objects known to be in our galaxy, like stars and globular clusters. When combined with the other evidence available, this strongly supports the cosmological distance scale over the galactic one.

The best statistics on bright gamma-ray bursts, which presumably look bright because they lie relatively nearby, came from an instrument on the Pioneer Venus Orbiter spacecraft. That gamma-ray burst detector recorded more than 200 strong bursts during its 13 years of operation. It found that the strong bursts were uniformly distributed out to some distance, meaning that the average number of sources in any given volume stayed constant.

Astronomy: Thomas L. Hunt

Bursts Originate in our Galaxy

One of the more important pieces of evidence is the isotropy of the bursts — they seem to arrive at Earth from all directions and show no preferred direction, as shown by the map at the beginning of this story. The BATSE (Burst and Transient Source Experiment) instrument on the Compton Gamma Ray Observatory revealed the isotropy and also confirmed previous studies showing that the bursts were not distributed uniformly in space. This implies that Earth lies at or near the center of the burst sources and that the intrinsic brightness and/or density of sources decreases with greater distance.

The March 5, 1979 event demonstrates that high-velocity neutron stars in the galactic halo can produce events that have the energy, spectrum, and duration of gamma-ray bursts.

There's no question that these findings are consistent with the cosmological hypothesis and that they are not consistent with a population of sources lying in the Galaxy's disk. But they *are* consistent with the galactic hypothesis if the bursts arise in an extended halo around the Galaxy.

Recent studies show that as many as half of neutron stars have speeds greater than 800 kilometers per second. However, the escape velocity from the Galaxy is only about 600 km/sec in the galactic bulge, where most neutron stars are born, and 500 km/sec in the solar neighborhood. That means all these high-velocity neutron stars will escape from the Galaxy. They form a distant, previously unknown "corona" around the Milky Way. This distant corona contains an ample population of sources that appear isotropic when viewed from Earth.

What of the Andromeda Galaxy, a bright galaxy similar to our own lying only 700 kiloparsecs (kpc) away? (One kiloparsec equals 3,260 light-years, so the Andromeda Galaxy lies 2.2 million light-years away.) It should have its own collection of high-velocity neutron stars, and some of them will travel toward us. When they produce gamma-ray bursts, BATSE should detect them.

However, some gamma-ray-burst models postulate that bursts are beamed along the direction of motion of the neutron star. If true, only the rare neutron star moving almost directly toward us would be seen by BATSE. The few resulting bursts from Andromeda always would be swamped by bursts from the many high-velocity neutron stars born in the Milky Way and moving away from us.

Even if the bursts radiate in all directions, detailed calculations show that BATSE would not yet have detected an excess toward Andromeda. A larger sample of BATSE bursts or a more sensitive instrument may one day reveal such an excess. If so, this would prove that bursts arise in the Galaxy. However, the lack of an excess would not prove the bursts lie at cosmological distances because they could still be beamed along the directions of the sources' motion.

Where do we stand so far in weighing the evidence? The BATSE observations of the sky and brightness distributions give no advantage to either the cosmological or galactic hypothesis. To resolve the question, we have to examine other evidence.

The most telling piece of additional evidence is that high-velocity neutron stars can generate bursts similar to gamma-ray bursts. Three of these neutron stars, all of them remnants of fairly recent supernovae, produce high-energy bursts that last as long as gamma-ray bursts and contain photons having only slightly less energy. Two of these so-called soft gamma-ray repeaters lie in our galaxy's disk at distances of tens of kpc; the third lies in the Large Magellanic Cloud at a distance of 50 kpc. And two of the repeaters lie well away from the centers of their respective supernova remnants, implying speeds of roughly 1,000 km/sec. Clearly, high-velocity neutron stars can produce burstlike behavior.

But one of these bursts stands above all the others. On March 5, 1979, the soft gamma-ray repeater known as SGR 0526–66 in the Large Magellanic Cloud let loose with a remarkable burst. After an intense initial spike lasting about 0.2 second, the burst continued at lower levels for another 200 seconds with brighter flashes every 8 seconds. The 8-second period and the burst's location within a young supernova remnant (N49) leave little doubt that the source was a neutron star. In addition, the pulsations imply a strong magnetic field.

Although nine different satellites observed the March 5 event, the initial spike proved so intense that it overwhelmed the detectors. However, astronomers working with sophisticated computers recently managed to analyze the burst's spectrum and found it looked just like that of a gamma-ray burst. You can argue whether this event was a gamma-ray burst or something unique, but either way, it shows that high-velocity neutron stars in the galactic corona can generate events that have the energy, spectrum, and duration of gamma-ray bursts. This evidence weighs heavily on the side of the galactic hypothesis.

Bursts Arise in the Distant Universe

The BATSE instrument on the Compton Gamma Ray Observatory helped confirm this finding, but it also gave insight into weaker and presumably more distant bursts because it is far more sensitive than Pioneer Venus Orbiter or other instruments. BATSE has found a relatively small number of these weak bursts, indicating that their numbers go down at large distances or that space takes on a different character.

These results — the isotropic distribution of bursts in the sky and the apparent shortage of weak bursts in all directions — must be considered together. When they are, the evidence strongly suggests that Earth lies at or near the center of a spherically symmetric and bounded distribution of gamma-ray bursters.

But how do we interpret this data? Given astronomers' almost total ignorance of what gamma-ray bursters are and what makes them burst, let's use a standard astronomical approach to determine the distances to the bursts.

Billions of stars, galaxies, and other objects inhabit the sky. Astronomers recognize literally hundreds of different types of objects. But only a few distinctly different types of distributions exist. Astronomers find a new class of object almost every year. But a fundamentally new distribution has not been found in decades.

All known objects in the inner solar system concentrate toward the ecliptic (the plane of Earth's orbit around the Sun): the orbits of all planets, asteroids, zodiacal dust, and comets in the Kuiper belt. Moving beyond our solar system, the nearby stars are more-or-less uniformly distributed in space, apart from their tendency to 'cluster' in binaries and multiple systems. They show an almost isotropic distribution.

> The distribution of bursts matches those of galaxies and quasars, but is inconsistent with those of any objects known to be in our galaxy.

When you include more distant stars, they tend to concentrate near the galactic plane. Likewise, plotting the positions of planetary nebulae and supernova remnants shows they also concentrate in the galactic plane, proving that they also belong to the Galaxy.

The astronomical inventory also contains objects in the Galaxy's halo. Among these are the globular clusters, the oldest components of our galaxy. They have a nearly spherical distribution reaching out to tens of kpc. However, their positions in the sky concentrate strongly toward the Galaxy's center because they are spherically distributed around the galactic center, not around Earth. All halo objects known exhibit this same property.

Astronomers have seen all these galactic objects — stars, planetary nebulae, globular clusters — in the nearby galaxies. This holds true for all galactic objects known: none resides only in our galaxy and all can be found in other galaxies, as long as they are luminous enough to be detected.

If we extend our gaze to the nearby galaxies, they seem to be strongly clustered. (In fact, most nearby galaxies belong to the Virgo Cluster.) Looking farther out, the overall distribution of more distant galaxies becomes more and more uniform, though they still cluster to some extent. Only radio surveys of very luminous radio galaxies and quasars, which can be detected at cosmological distances, show an isotropic and random distribution over the sky.

Of all the many types of objects known to astronomers, only two show both random (not clustered) and isotropic distributions: nearby stars and very distant extragalactic objects. The distributions of every type of object in between reveal either the structure of the Galaxy or the local signature of the large scale structure of the universe.

What does this have to say about the distribution of gamma-ray bursts? Before BATSE, astronomers knew that the bursters were distributed uniformly not only over the whole sky but also in distance. There was no way to choose between the galactic and cosmological distance scales. With BATSE's very high sensitivity, however, everyone expected the weaker, more distant bursts to come into view and resolve the puzzle: if the weak bursts concentrated in the Galaxy's plane, the sources lay in the Galaxy; if not, they lay in the distant universe.

When BATSE found no concentration of the weak sources toward either the galactic plane or the galactic center, the debate should have been over. But proponents of the galactic hypothesis have proved resourceful.

Their current idea holds that gamma-ray bursts come from high-velocity neutron stars lying in an extended galactic corona. These neutron stars presumably formed in supernova explosions that ejected them in random directions from their birthplaces in the galactic disk.

But problems exist with this scenario as well. The high-velocity neutron stars could certainly reach great distances, but they would have a spherical distribution around the Galaxy's center and the number of bursts doesn't seem to increase in that direction. Because neutron stars are born in the Galaxy's disk, most within a few kpc of the galactic center, the BATSE data should show a concentration in that direction.

Bursts Originate in our Galaxy

However, that's not all the soft gamma-ray repeaters have to offer on the subject. As their name suggests, these repeaters don't emit just one burst and then go silent — they burst repeatedly at intervals ranging from days to years. Until recently astronomers thought that gamma-ray bursters did not repeat at all, but that's not the case anymore. Statistical studies made on the first catalog of BATSE sources, whose positions are known to only about 7 degrees, support the idea that gamma-ray bursts do repeat.

If high-velocity neutron stars give rise to gamma-ray bursts, then they must repeat — there simply aren't enough neutron stars in the galactic corona otherwise. To account for the number of bursts seen each year, each neutron star must burst at least ten thousand times during its life.

On the other hand, repeating presents severe problems for cosmological models. If the bursts lie at such vast distances, they must consume enormous amounts of energy. And in most of the widely studied models, such as coalescing neutron stars in binary systems and failed supernovae, the source itself gets destroyed.

The lack of any bright optical counterparts for gamma-ray bursts adds another piece of evidence favoring the galactic hypothesis. Although BATSE can't pinpoint burst locations, the network of burst detectors on several interplanetary spacecraft can. By measuring the arrival times of bursts at spacecraft spread across the solar system, this interplanetary network has allowed astronomers to derive accurate positions for a number of bright bursts. But when optical astronomers search these "error boxes," they often find no bright object within them. Of course you wouldn't expect to see anything if high-velocity neutron stars in the galactic corona cause the bursts. At a distance of 100 to 500 kpc, a quiescent neutron star with a typical diameter of a few kilometers would appear extremely faint.

The dearth of bright optical counterparts poses a severe problem for cosmological models, however. The brightness distribution of gamma-ray bursts implies that the bright bursts lie relatively nearby, at redshifts of 0.1 to 0.2 (distances of a couple billion light-years); any bright galaxy in the error box should be easily visible. Their absence rules out cosmological models involving either normal galaxies or active galactic nuclei.

One piece of evidence often cited as supporting the cosmological hypothesis is the apparent stretching of faint bursts. Several studies report that faint bursts, which presumably lie farther away, last about twice as long and have peaks about twice as wide as bright bursts. Some astronomers interpret the time stretching to be a result of cosmological time dilation. In other words, the expansion of the universe makes the sources of these faint, distant bursts recede more rapidly from Earth, and the great speed lengthens the apparent duration in accordance with Einstein's theory of relativity. But the difference is not a unique signature of cosmological time dilation, and therefore of a cosmological origin for the bursts.

Moreover, if cosmological time dilation causes the entire time stretching, the burst sources must lie at a redshift of about 6. That corresponds to a distance greater than the most distant galaxies or quasars and implies that the bursts must originate before the first stars or galaxies formed. If the sources lie much closer than that, then well over half of the reported difference in the widths of the peaks of faint and bright bursts must be intrinsic to the burst. And if most of the difference is intrinsic, there's no reason to think all of it isn't. Consequently, the reported time stretching supports neither the cosmological or galactic hypothesis.

> A number of scientists have found significant evidence that gamma-ray bursts repeat on time scales of days to months, which *clearly* favors the galactic hypothesis.

So where do we stand in weighing the evidence? A galactic corona of high-velocity neutron stars can give rise to the isotropic distribution of sources seen by BATSE, just as cosmological sources can. But the galactic hypothesis really shines when you consider the similarities between gamma-ray bursters and the soft gamma-ray repeaters; the origin of the March 5, 1979 event in a high-velocity neutron star; the possibility that gamma-ray bursts repeat; and the lack of any bright optical counterparts to gamma-ray bursts. When you add up all of the evidence, the balance tips strongly toward a galactic origin for gamma-ray bursts. ☐

This article is based on a debate, "The Distance Scale to Gamma-Ray Bursts," between Don Lamb and Bohdan Paczynski held in Washington, D. C., last April.

Bursts Arise in the Distant Universe

In order for gamma-ray bursts to appear isotropic despite Earth's 8-kpc distance from the galactic center, the number density of bursters must remain constant for at least 30 kpc in all directions. There doesn't seem to be any satisfactory explanation for the extent of this uniform-density region. On the other hand, a cosmological distance scale to gamma-ray bursters automatically satisfies the observed distribution.

What about the purported similarities between gamma-ray bursters and soft gamma-ray repeaters? The three soft gamma-ray repeaters known all appear associated with supernova remnants, two in our galaxy and one in the Large Magellanic Cloud. Astronomers believe them to be young, high-velocity neutron stars having extraordinarily strong magnetic fields. Judging from their supernova remnants, they probably are about 10,000 years old.

Unfortunately, these objects appear to have little in common with gamma-ray bursters. The spectra of the bursts from the two kinds of object look completely different, they have characteristic energies that often differ by many thousands of times, and the gamma-ray bursts don't seem to repeat. Only the unique March 5, 1979 event that emanated from the repeater SGR 0526–66 in the Large Magellanic Cloud could be classified as a gamma-ray burst on the basis of its spectrum and time variability.

Linking gamma-ray bursts to the March 5 event and hence to the soft gamma-ray repeaters doesn't work, however. It's impossible to reconcile the isotropic distribution of gamma-ray bursts with ages of about 10,000 years — the neutron stars simply wouldn't have enough time to move far from their birthplaces in the galactic plane.

So to hold onto a galactic origin of gamma-ray bursts, you have to assume that for some unknown reason the bursts from young, high-velocity neutron stars stop after about 10,000 years and then resume again after 10 million to 100 million years. Then add to that requirement the necessity of having the bursters turn on at just the right ages so that they would appear to have a uniform number density within 30 kpc of the galactic center.

The March 5 event was so intense that it could easily have been seen out to the Andromeda Galaxy, and far beyond it. But no trace of M31 exists in the sky distribution of gamma-ray bursts. That means making another assumption: gamma-ray bursts have to be a few orders of magnitude less intense than the March 5 event. And you'd better have them stop bursting after a few hundred million years, otherwise those born in M31 would have reached our galaxy and shown up in the data. Either that, or hide the bursts from M31 by postulating that the burst's emission gets beamed along the direction of the source's motion.

So many *ad hoc* assumptions are needed to make the proposed coronal distribution of gamma-ray bursters consistent with the observations that it doesn't seem to be a viable scientific proposition.

One other observation supports the cosmological hypothesis. If the bursts are at great distances, the expansion of the universe should cause them to be redshifted. Two effects could be noticed: weaker bursts should appear to last longer than brighter ones and their spectra should appear softer. Although both effects reportedly have been found in the data, some doubts remain. It will take some time before astronomers reach a consensus on the presence or absence of this effect, and on its interpretation.

Why are no obvious optical counterparts seen to gamma-ray bursts? That's hard to say — particularly because we have no idea what causes the bursts. However, most arguments against the cosmological distance scale hinge on models.

The opponents always have a specific model in mind when claiming that bursters can't lie a few billion pc away. And often their argument is correct, but only for that particular model. Because we really have no idea what gamma-ray bursters are or what makes them burst, we have to use a method independent of models if we want to determine their distance.

We have strong evidence that gamma-ray bursts are at cosmological distances, and *no* evidence for any other distance scale.

We can summarize the distance-scale debate as follows: astronomers have strong evidence that gamma-ray bursters lie at cosmological distances; no evidence that they don't lie at these distances; and no evidence that they lie at any other distance. However, astronomers still have no *proof* that bursts lie at cosmological distances. And until the next generation of gamma-ray satellites starts returning data, we likely won't resolve this debate. □

What do you think of the opposing viewpoints? ASTRONOMY is conducting a non-scientific poll of its readers to see which side of the debate they favor. You can vote by letter, postcard, e-mail, or at our site on the World Wide Web (http://www.kalmbach.com/astro/astronomy.html).

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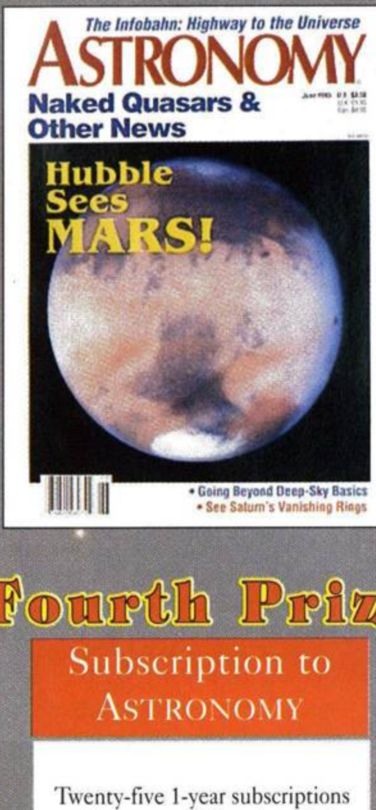
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SKY ALMANAC

Several planets cluster low in the evening twilight, but the big event is a good show of Geminid meteors on mid-December evenings.

by Deborah Byrd

Highlights
by Rick Shaffer

Date	Event
13	The Geminids Triumph over a Gibbous Moon . . . *(p. 64)*
17	Asteroid Hebe Occults a Star . . . . *(p. 70)*

All month:

The Bright Asteroid Amphitrite Comes to Opposition . . . *(p. 70)*

First Views:

Two Beautiful Winter Clusters . . . . . *(p. 71)*

A Comet for Winter Evenings. . . . . *(p. 73)*

Observer's Challenge:

Saturn's Ghostly Rings . . . . *(p. 72)*

The Starry Sky:

Auriga. . . . . . . *(p. 69)*

This month the evening sky begins to take on the look of winter. The souls of stargazers across the globe are reopening to the glories of this part of the sky, the region opposite to the center of the Galaxy.

Many of the bright stars now visible in the evening form familiar patterns to those who watch the skies. Orion the Hunter ranks as perhaps the best known star pattern in the Northern Hemisphere, except for the Big Dipper. Ask a novice to pick out any pattern of stars in the winter evening sky, and he or she will almost always choose Orion. That's because Orion — with its bright stars ruddy Betelgeuse and blue-white Rigel and its short, straight row of three medium-bright "belt" stars — appears so striking.

Rigel (on Orion's lower right corner) also takes part in a much larger pattern, or asterism, consisting of most of winter's brightest stars. Together with Sirius in the constellation Canis Major, Procyon in Canis Minor, Pollux and Castor in Gemini, Capella in Auriga, and Aldebaran in Taurus, Rigel makes a pattern known as the Winter Circle. Even with the naked eye, you can notice the different colors of these stars.

You can use the Winter Circle to gain a perspective on our place in the Milky Way Galaxy. Of course, the Galaxy surrounds us in space, and so stars appear in all directions. But because it is disk-shaped, like a pancake, we see many more stars when we look edgewise into the plane of the Galaxy than when we look up or down out of it. The Winter Circle stars lie very close to the galactic plane, residing in the spiral arm containing the Sun and in the next one out from the Galaxy's center. Under a dark country sky, you can pick out the starlit trail of the Milky Way arcing delicately through these stars.

But enough of the distant stars for now. Let's reel in our perspective to just the Sun's family of planets. These are a few hundred thousand times closer to home than any of the stars. Many of the planets in our solar system now lie in the evening sky too. But before talking about these mighty worlds, I should mention some tiny particles in orbit around the Sun whose fiery fates will liven mid-December evenings.

In the course of its yearly orbit around the Sun, Earth fords a number of meteor streams. These are streams of particles, each about the size of a grain of sand, left behind by comets. Earth encounters each stream of cometary debris at about the same time every year. When the particles enter the atmosphere, they vaporize from friction with the air, producing bright

The Geminids Triumph over a Gibbous Moon

Lynn Carroll

The night of December 13/14 brings with it the peak of this year's Geminid meteor shower. The bad news is that the Moon will then be just short of Last Quarter phase, washing the sky with unwanted light after midnight. The good news is that the Geminid shower is one that's just as good before midnight as after. So at least until the Moon rises around 11 p.m., naked-eye observers should be in for an excellent show. Expect to see a few dozen bright meteors per hour, the majority of them white but with many yellow and some blue, orange, red, and green ones.

The Geminid meteor stream orbits the Sun with a period of about 1.65 years. The point where the stream's orbit intersects Earth's orbit lies in the constellation Gemini, hence the shower's name. The meteors zip into Earth's atmosphere along nearly parallel lines, but from our perspective, they appear to radiate away from the intersection point as if from a "meteor spigot." To get the best view of the shower, face eastward but look about halfway between Gemini and straight overhead.

Because December nights are often chilly, dress warmly (or lie in a sleeping bag) and bring along some hot coffee, tea, or chocolate in a thermos. Many meteor watchers I know use a pickup truck as a wind shield. Just park the pickup pointing away from the shower's radiant, put a lawn chair in the bed, and climb into a sleeping bag. The cab shields you from some of the winter wind, while the Geminids provide the fireworks. — *Rick Shaffer*

1995

DECEMBER

5 Asteroid Psyche is at opposition

6 Full Moon is at 8:27 p.m. EST

9 The Moon is at apogee (252,478 miles from Earth), 5:14 a.m. EST

14 Geminid meteor shower peaks (page 64)

15 Last Quarter Moon is at 12:31 a.m. EST

16 Venus passes 2° south of Neptune, noon EST

18 Jupiter is in conjunction with the Sun, 5 p.m. EST

20 Venus passes 1.3° south of Uranus, 8 a.m. EST

21 New Moon is at 9:22 p.m. EST

22 Winter solstice is at 3:17 a.m. EST
Asteroid Amphitrite is at opposition (page 70)
The Moon is at perigee (221,704 miles from Earth), 5:07 a.m. EST

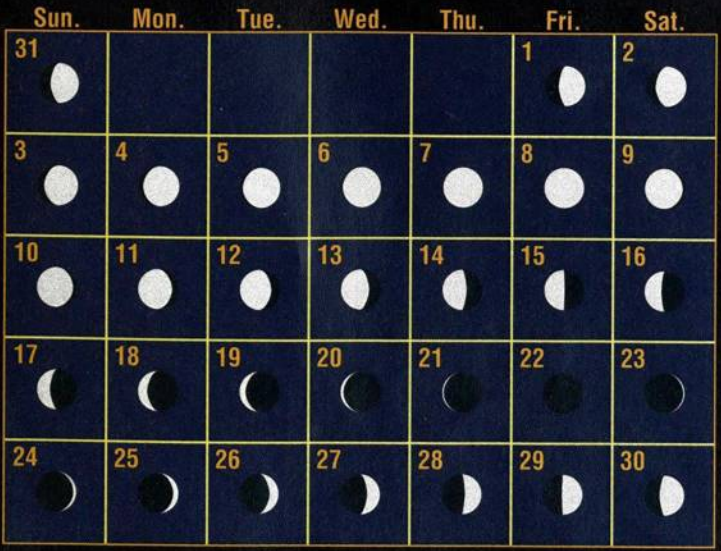
23 The Moon passes 7° north of Mercury, 2 a.m. EST
The Moon passes 6° north of Mars, 2 a.m. EST
Mercury passes 1.1° south of Mars, 4 a.m. EST
The Moon passes 5° north of Neptune, 1 p.m. EST
The Moon passes 6° north of Uranus, 9 p.m. EST

24 The Moon passes 7° north of Venus, 5 a.m. EST
Comet Honda-Mrkos-Pajdusáková is at perihelion
(49.4 million miles from the Sun)

27 The Moon passes 5° north of Saturn, 10 a.m. EST
Mercury passes 2° south of Neptune, 9 p.m. EST

28 First Quarter Moon is at 2:06 p.m. EST

31 Mercury passes 0.9° south of Uranus, 8 p.m. EST



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
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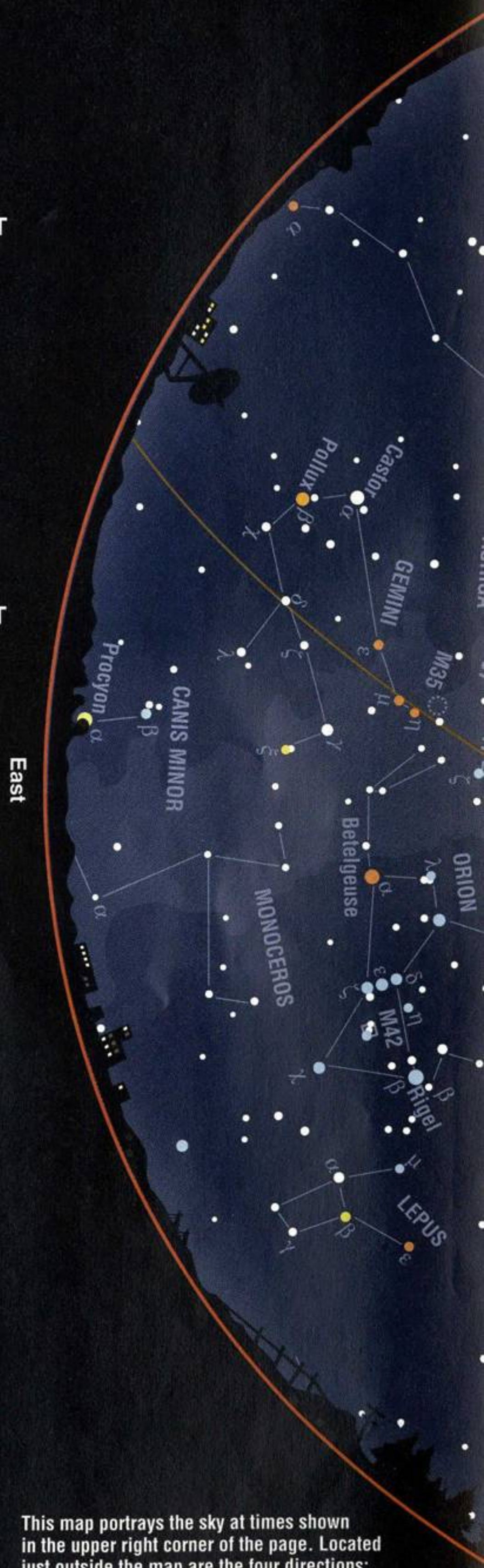
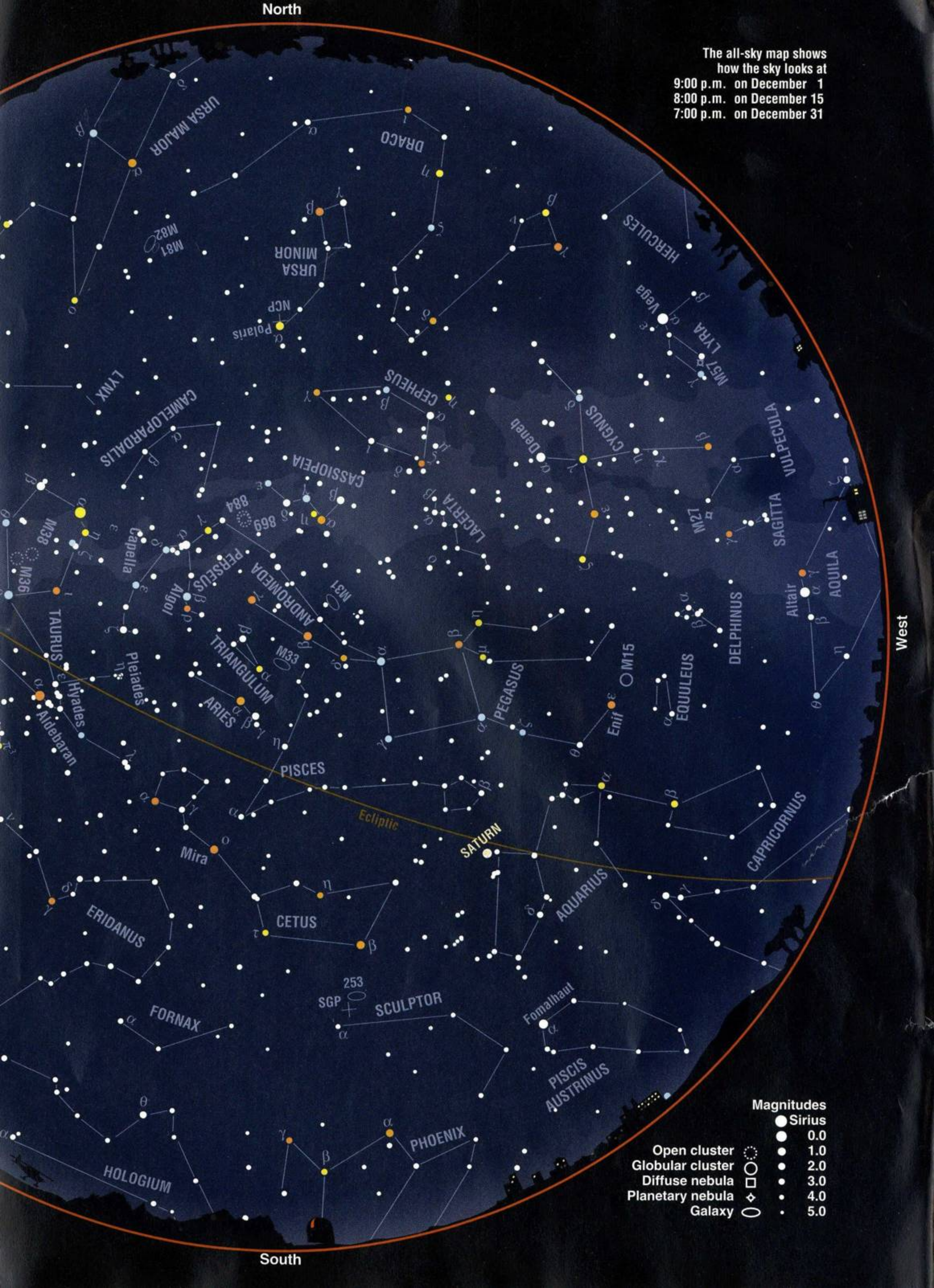


This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



The all-sky map shows how the sky looks at
9:00 p.m. on December 1
8:00 p.m. on December 15
7:00 p.m. on December 31

North
South
West
URSA MAJOR
DRACO
M81
M82
URSA MINOR
NCP
Polaris
HERCULES
Vega
LYRA
M57
LYNX
CAMELOPARDALIS
CEPHEUS
CYGNUS
Deneb
VULPECULA
CASSIOPEIA
SAGITTA
M27
884
869
M38
M36
Capella
PERSEUS
LACERTA
ANDROMEDA
M31
Algol
TAURUS
TRIANGULUM
M33
Pleiades
Hyades
Aldebaran
ARIES
PEGASUS
M15
Enif
EQUULEUS
DELPHINUS
Altair
AQUILA
PISCES
Ecliptic
SATURN
CAPRICORNUS
Mira
AQUARIUS
ERIDANUS
CETUS
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SCULPTOR
FORNAX
Fomalhaut
PISCIS AUSTRINUS
PHOENIX
HOLOGIUM
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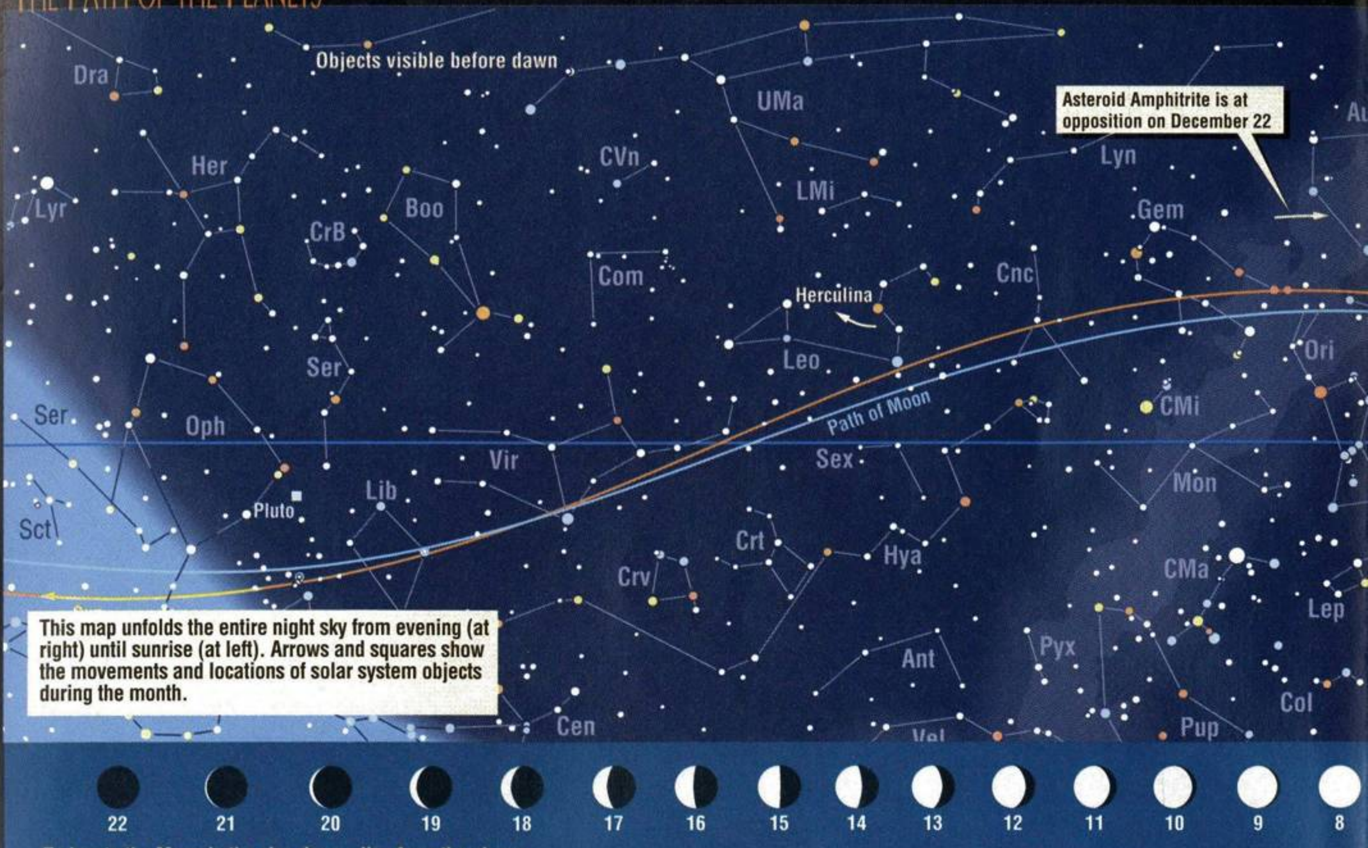
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Objects visible before dawn
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Asteroid Amphitrite is at opposition on December 22

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

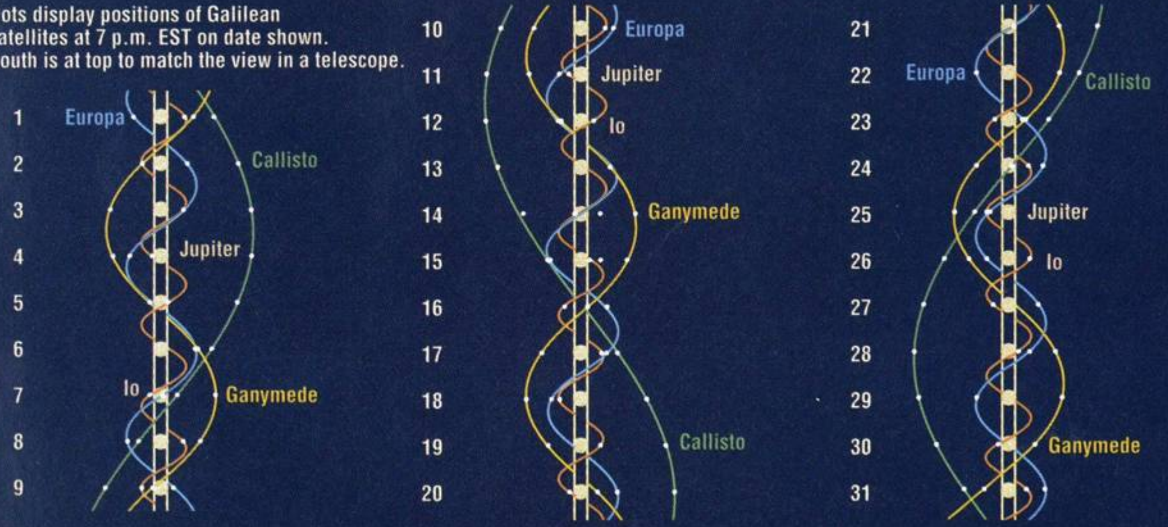
To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

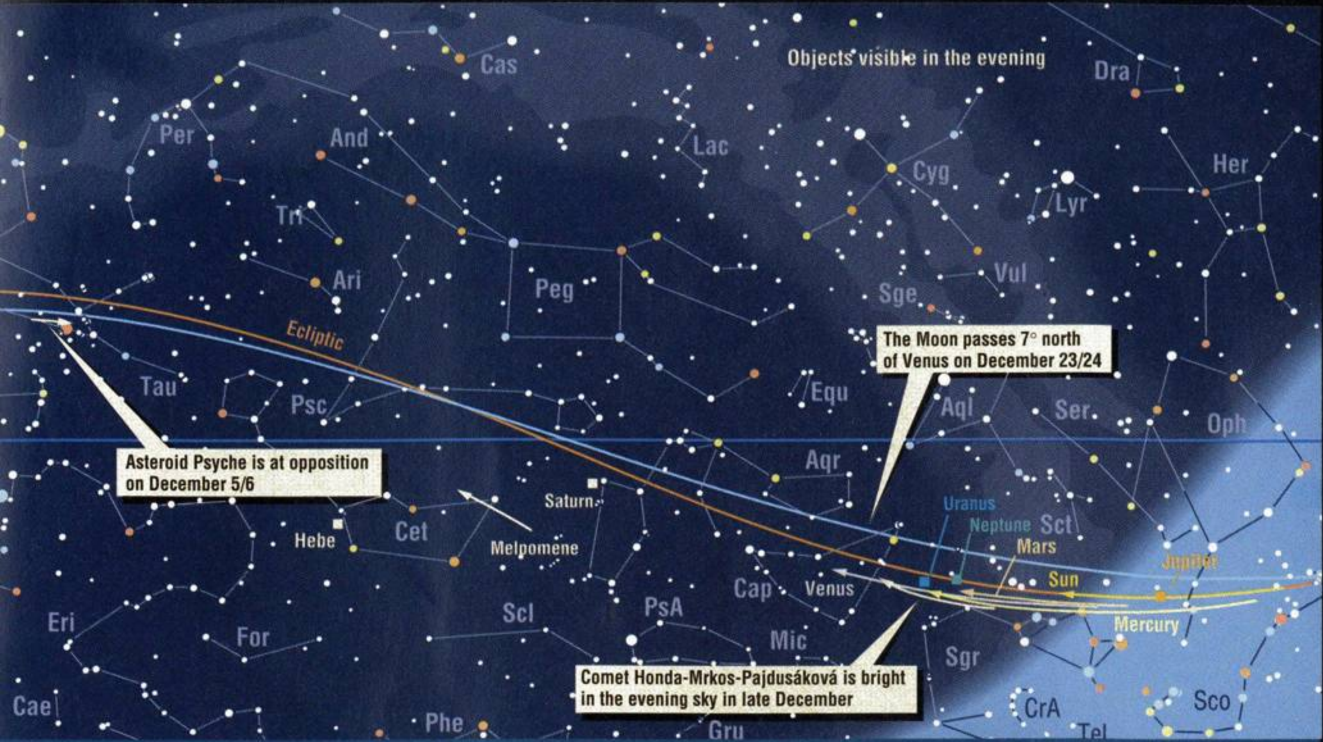
10"

PLANETS	MERCURY	MERCURY	VENUS	MARS	JU
Date	December 15	December 31	December 15	December 15	Dece
Magnitude	–0.7	–0.6	–4.0	1.3	–
Angular Size	5.0"	6.4"	11.9"	4.1"	3
Illumination	94%	69%	88%	99%	1
Distance (AU) from Earth	1.343	1.058	1.407	2.311	6
Distance (AU) from Sun	0.433	0.348	0.728	1.413	5
Right Ascension (2000.0)	18h20.1m	20h01.7m	19h34.9m	18h48.5m	17h
Declination (2000.0)	–25°32'	–22°05'	–23°23'	–24°00'	–2

JUPITER'S MOONS

Dots display positions of Galilean satellites at 7 p.m. EST on date shown. South is at top to match the view in a telescope.

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Cet
Melpomene
Cap
Venus
Mercury
Eri
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Sgr
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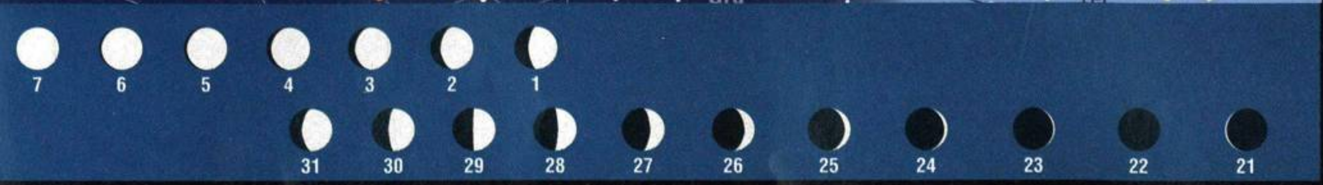
Objects visible in the evening

The Moon passes 7° north of Venus on December 23/24

Asteroid Psyche is at opposition on December 5/6

Comet Honda-Mrkos-Pajdusáková is bright in the evening sky in late December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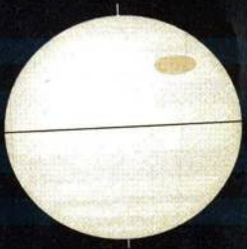
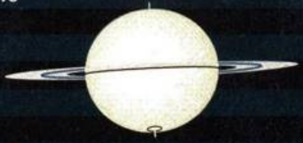
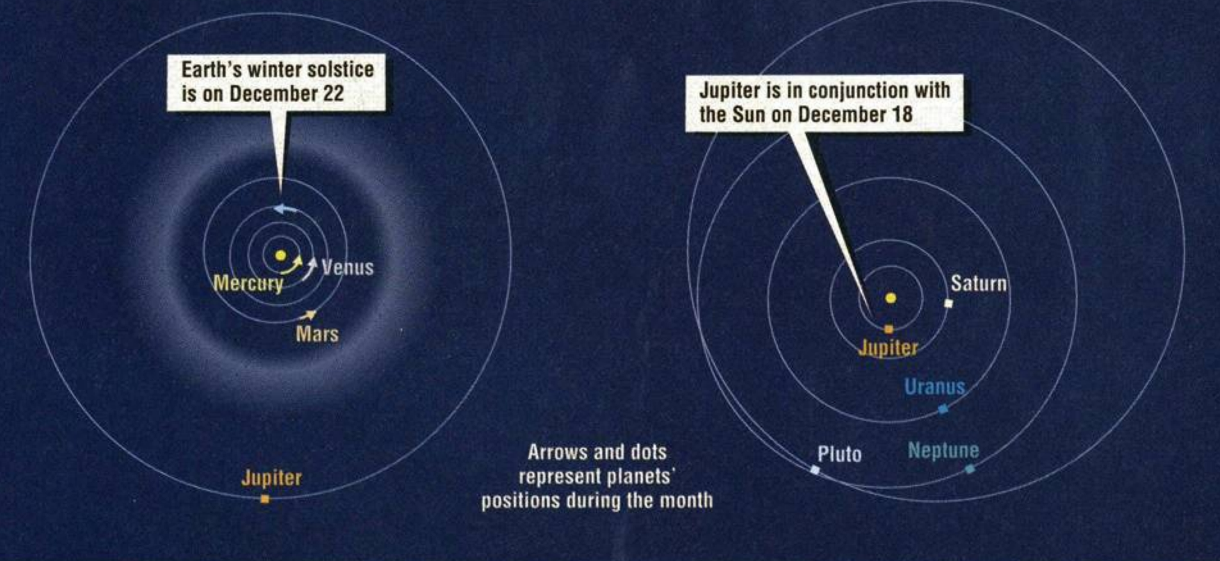




TER	SATURN	URANUS	NEPTUNE	PLUTO
ber 1	December 15	December 15	December 15	December 15
8	1.1	5.9	8.0	13.8
6"	17.3"	3.4"	2.2"	0.1"
%	100%	100%	100%	100%
31	9.602	20.532	31.000	30.765
30	9.583	19.744	30.166	29.873
.4m	23h21.2m	20h02.9m	19h43.8m	16h07.6m
56'	–6°32'	–20°59'	–20°48'	–7°52'

THE PLANETS IN THEIR ORBITS


Mercury
Venus
Mars
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Earth's winter solstice is on December 22

Jupiter is in conjunction with the Sun on December 18

Arrows and dots represent planets' positions during the month streaks of light in the night sky known as shooting stars, or meteors. When Earth crosses a meteor stream, we experience an annual meteor shower.

One of the year's best meteor showers, the Geminids, peaks on the night of December 13/14, with somewhat fewer meteors visible a day or two before and after. Geminid meteors appear to radiate from the zodiacal constellation Gemini the Twins, from which they take their name.

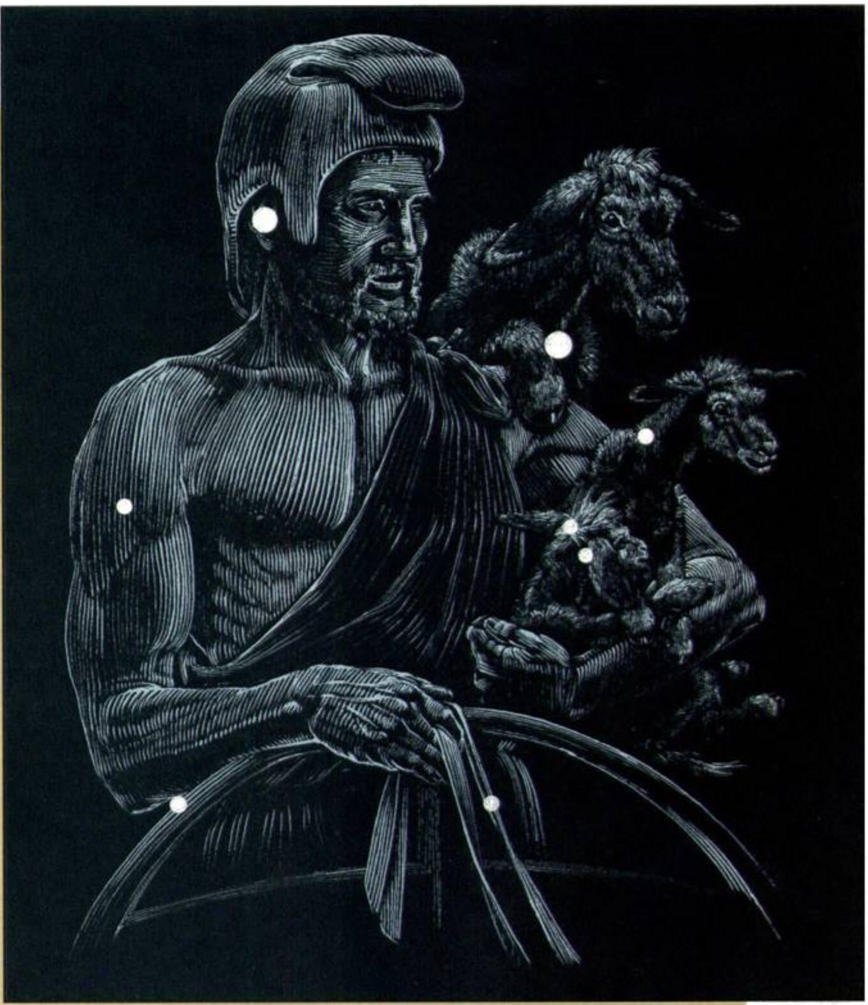
Although it's nice to know the whereabouts of this radiant, that knowledge isn't necessary to enjoy viewing the shower because most meteors don't become visible until they are some distance from this point. To fully appreciate any meteor shower, all you need is a dark sky, with no Moon and no city lights. Simply stretch out on a lawn chair and gaze attentively up at the sky. If any meteors happen to fly, you'll likely see them.

Most showers produce more meteors after midnight than before. That's because, after midnight, you're facing in the same direction as Earth's motion around the Sun. (The same effect causes more raindrops, or snowflakes, to hit the front windshield than the rear when you drive through a storm.) The Geminid meteor stream encounters Earth's orbit at an unusual angle, however. The meteors hit the atmosphere from the side, with one effect being that the shower's radiant rises in mid-evening rather than after midnight. This means you often see as many Geminids before midnight as after.

This year that's a good thing, because the Moon rises a little before midnight at the shower's peak. On the night of December 13/14, the Moon appears slightly more than half lit as it wanes toward Last Quarter. You'll want to watch when the Moon is absent from the sky, from mid-evening until moonrise.

The December evening sky also plays host to a number of planets. You can find

The Starry Sky: **Auriga**



Keith Ward

Lying high in the northeast on these December evenings, you'll find a distinctive five-sided figure. This prominent pattern, shaped like an irregular pentagon, forms the constellation Auriga the Charioteer.

In Greek mythology, Auriga is associated with a mythical king of Athens, Erichthonius. He was the unwanted son of the goddess of wisdom, Athena, following her rape by Hephaestus, god of fire. Athena supposedly raised the child by keeping him in a chest guarded by snakes. He grew to manhood and became a king, but — perhaps in keeping with the Greek mythological tradition of translating psychological traits into physical features — Erichthonius was forever crippled. That's why he found a need to invent the chariot.

Auriga contains the sky's sixth brightest star, Capella the Goat Star. This luminary lies in the northwest corner of the constellation and is closer to the north celestial pole than any other of the sky's brightest stars. For observers in mid-northern latitudes, this northerly location places Capella where it can be seen at some time of the night during every month of the year.

Because Capella shines with a golden light, I always think of it as looking much like our Sun would look, if we were standing on a planet orbiting Alpha Centauri or some other nearby star. In fact, however, Capella is far different from the Sun (see "Compelling Capella," February 1995). It actually consists of two nearly identical giant stars that orbit no farther from each other than the planet Venus does from the Sun. Both of these stars have more than twice the mass of the Sun, and thus shine much more brightly. They lie some 43 light-years from our solar system.

Auriga contains an asterism worth getting to know. Called the Kids, it is a small triangle of stars located a few degrees southwest of Capella.

The most interesting of these three stars is 3rd-magnitude Epsilon Aurigae, the northernmost of the Kids. Once every 27 years (most recently in 1982), this star undergoes a dramatic dimming. Then it fades by nearly a magnitude over a period of about six months, remains dim for approximately a year, and then grows gradually brighter again.

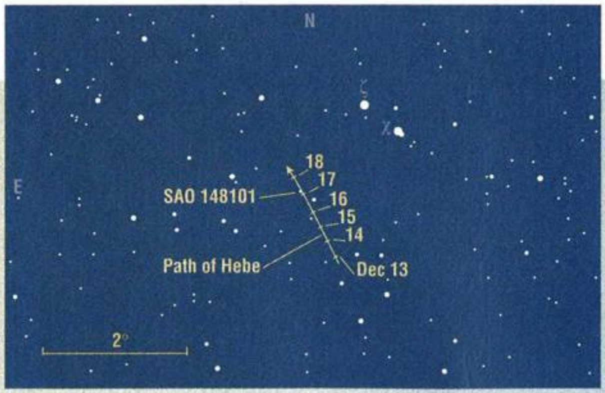
Astronomers think an enormous, dark unseen companion object causes this bizarre dimming. It must orbit Epsilon once every 27 years, but moves so slowly that it takes more than a year to pass in front of Epsilon as seen from Earth.

Over the years, many have speculated on the nature of this hypothetical companion. Astronomers once believed it to be a star several thousand times larger in diameter than our Sun. More recently, some astronomers have suggested that Epsilon's companion may be a huge shell or disk of gas and dust surrounding a more ordinary star. Many of you reading this column will no doubt hear additional speculations, particularly as we approach the next dimming around the year 2009. — *Deborah Byrd*

Asteroid Hebe Occults a Star

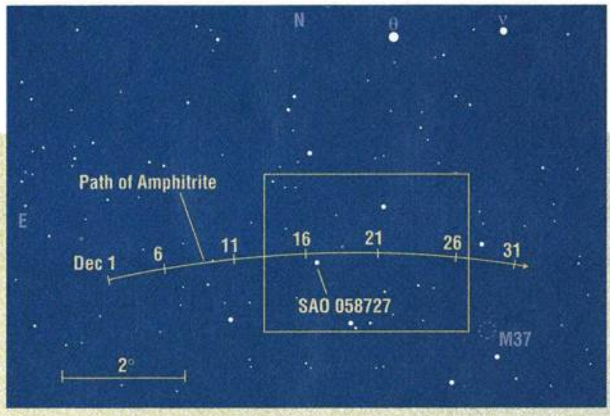
Observers in the northwestern United States have the chance to see a subtle but exquisite sight on the night of December 17/18, when asteroid 6 Hebe occults the 8.5-magnitude star SAO 148101 in central Cetus. Anyone with a small telescope should be able to watch as the asteroid approaches and then covers the star, causing the combined light from the objects to drop a full magnitude, or by some 60 percent.

Astronomers predict that the occultation should be visible along a path running from the southern coast of Oregon northeast into southeastern Washington, northern Idaho, and northwestern Montana. I say "predicted" because Hebe's orbit isn't known accurately enough to nail the path of the shadow. About all that can be said with certainty is that the path will be just about as wide as Hebe's diameter, approximately 200 km.



Hebe passes in front of SAO 148101 for just 18 seconds at 11:45 p.m. PST on the 17th (12:45 a.m. MST on the 18th). (The asteroid positions shown in the map are for 10 p.m. EST, 9 p.m. CST, 8 p.m. MST, and 7 p.m. PST. The star lies at right ascension 1h54m54s and declination −11°30'41".) With the uncertainty in the shadow's path, anyone in the northwestern United States should take a look on the chance they might see the occultation. Even if the shadow misses your locale, the sight of Hebe passing right next to the star will be worth viewing. If you live farther east, you can still watch Hebe approach the star on the evening of the 17th. — *R.S.*

The Bright Asteroid Amphitrite Comes to Opposition



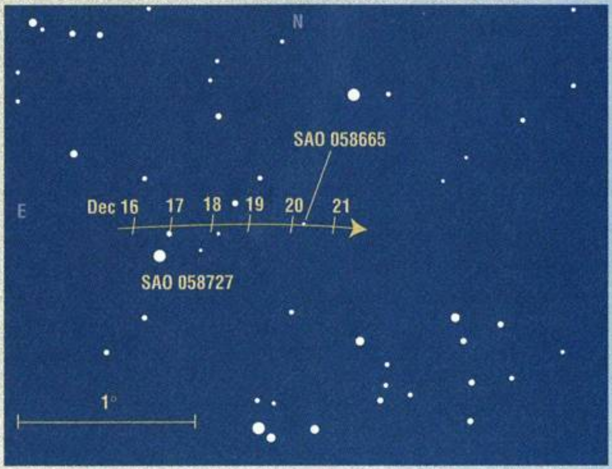
COORDINATES FOR AMPHITRITE

Date	R.A. (2000)	Dec.
December 1	6h21.9m	33°20'
December 6	6h17.3m	33°32'
December 11	6h12.1m	33°40'
December 16	6h06.5m	33°45'
December 21	6h00.6m	33°46'
December 26	5h54.8m	33°43'
December 31	5h49.2m	33°36'

Asteroid 29 Amphitrite slides westward through Auriga this month, coming to opposition against the star-rich Milky Way on December 22. The 195-km-wide minor planet glows at magnitude 8.9 at that time, easily within the range of binoculars or a small scope.

Just because it appears bright in a telescope, however, doesn't mean finding it will be easy. With the multitude of stars in this region, picking out which point of light is Amphitrite requires carefully comparing the eyepiece view with that shown on the chart above. (Positions in the chart and table are shown for 11 p.m. EST, 10 p.m. CST, 9 p.m. MST, and 8 p.m. PST.) If you can't differentiate the asteroid from the stars, sketch what you see in the eyepiece and return to the same field of view a night or two later. The object that has changed position will be Amphitrite.

As an added bonus this month, Amphitrite mimics Hebe by occulting a 9th-magnitude star on the night of December 20/21. Observers all along the United States-Canada border can see SAO 058665 (right ascension = 6h01m40s, declination = 33°46'08", in 2000.0 coordinates) wink out as Amphitrite passes in front of it. The shadow's path runs east to west, hitting the East Coast at about 2:08 a.m. EST on the 21st, the Midwest around 1:11 a.m. CST, the Rockies around 12:13 a.m. MST, and the West Coast around 11:14 p.m. PST on the 20th. At most, the star will disappear for 21 seconds and the combined light of the pair will drop 0.6 magnitude. — *R.S.*



Jupiter very low in the southwest right after sunset during the first week of the month. It sets less than an hour behind the Sun on December 1. A fainter object wouldn't be visible so low in the sky, but Jupiter shines brightly at magnitude –1.8. If you can't pick it up with the naked eye, try finding it with binoculars. On December 18, Jupiter passes on the far side of the Sun as seen from Earth, a configuration called conjunction.

When December begins, ruddy **Mars** stands about 8° above and to the left of Jupiter. Although it is higher in the evening twilight than Jupiter, at magnitude 1.3 it is also much fainter, so your chances of seeing it are probably no better than for seeing Jupiter. Your best bet for finding the Red Planet is to start looking no more than half an hour after sunset.

Mars disappears into the Sun's glare by the end of December, yet you may want to try to follow it with binoculars down to month's end. That's when the innermost planet, **Mercury**, emerges from the Sun's glare and sweeps past the Red Planet. Mercury passes 1.1° south of Mars on the evening of December 22, at about the same time the Moon sweeps north of the pair.

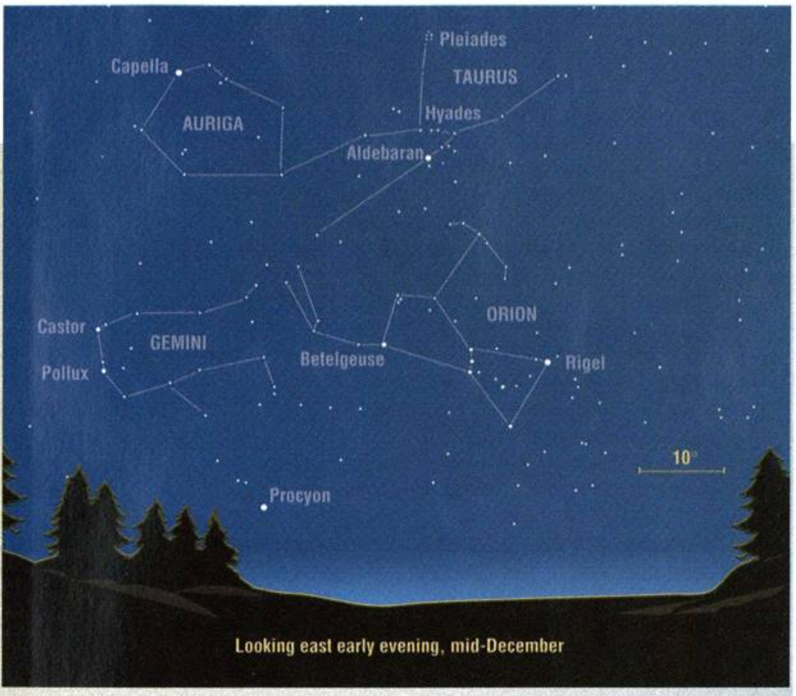
Mercury spends the last week or so of December climbing higher above the western horizon after sunset and will reach greatest elongation from the Sun in the first few days of the new year. Although it shines brightly, at magnitude –0.6 on December 31, it never gets very high in the sky during this evening apparition. Binoculars will be a real help in finding the sky's most elusive bright planet.

With so many planets lurking low in the western twilight, **Venus** easily ranks as this month's most prominent "evening star." Not only does it appear higher in the west after sunset with each passing day, at magnitude –4.0 it also appears a little brighter now than last month.

You might notice a 2nd-magnitude star near Venus during the first week of December. This is Nunki, in the handle of the Teapot asterism in the constellation Sagittarius.

Venus passes near two planets this month, but these so-called conjunctions take place beyond the limit of

First Views:
Two Beautiful Winter Clusters



Looking east early evening, mid-December

Although many wonderful open star clusters populate the summer sky, they seem to be the winter sky's stock-in-trade. Two that probably rank as best are the Pleiades and Hyades. Both are among the closest star clusters to Earth and thus are among the brightest. The Hyades form the head of Taurus the Bull, while the Pleiades form one of the horns.

The Pleiades contains ten stars brighter than 6th magnitude and another dozen or so brighter than 7th. Although in mythology the cluster represents seven sisters, people who observe from dark sites often see ten Pleiads with their naked eye. That's what I typically see, although on one memorable night I counted 14. With a small scope, that number jumps to 80 or more.

Because the cluster spans a degree and a half, you don't want to magnify the view a lot. Binoculars usually provide the best overall view, though a small telescope used at its lowest power will also show most of the cluster.

The brightest Pleiads are all hot B-type stars that spend their lives in the stellar fast lane: being born, living their lives, and burning out in a small fraction of the time taken by stars like the Sun. Their surface temperatures are about 20,000 kelvins, more than three times that of the Sun. They also spin very fast, on the order of 100 times the rate of our Sun, or about once every six hours. They lie roughly 400 light-years away and span approximately 7 light-years.

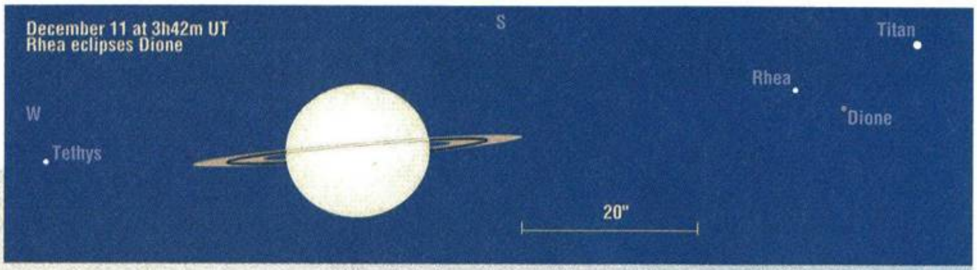
If you're new to observing the sky, the Pleiades should be one of the first objects you view. As practice improves your skills, you may notice that the Pleiades are embedded in a faint hazy nebulosity. On those rare nights when the atmosphere really settles down, this nebulosity begins to resemble the photographs, with wispy strands spreading out like the remains of a fireworks show.

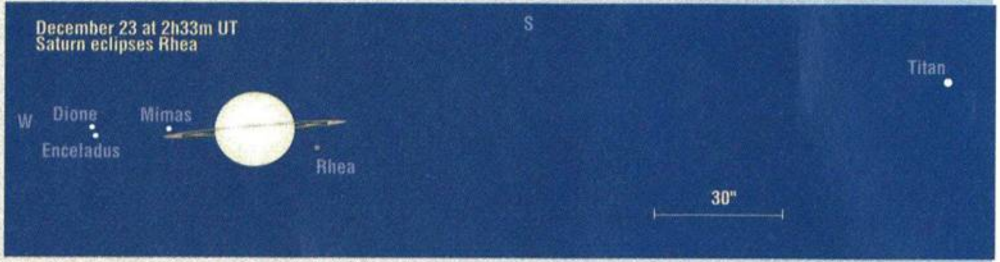
Because its stars spread out across the sky, many observers overlook the Hyades as an open cluster. The V-shaped group appears large because it's so close, only about 130 light-years away. Although it appears to be part of the Hyades as seen from Earth, ruddy Aldebaran actually lies about 60 light-years closer.

The "V" covers about 5° of sky, so you can just fit the cluster into the field of 10x70 binoculars. However, 7x50s do a better job. (And the naked-eye view isn't too shabby either!)

There's no nebulosity associated with the Hyades, but there are lots of bright stars: 15 members shine brighter than 5th magnitude. The total number of Hyades is hard to determine because they are members of a much larger group called the Taurus Moving Cluster that encompasses much of the constellation. The number is between 150 and 400, depending on how far out and how dim your count goes. — *R.S.*

Observer's Challenge:
Saturn's Ghostly Rings





The Sun and Earth now lie on opposite sides of Saturn's ring-plane, so a telescope this month will reveal the golden globe of the planet with a set of dim, ghostly rings surrounding it. The dimness of the rings presents a real observing challenge. To meet this challenge, take the following steps.

First, to minimize distracting scattered light, be sure the optics of your telescope are scrupulously clean. Second, pick an observing site and a night that promise good seeing. Your site should have no sources of heat turbulence, such as parking lots or buildings, between you and the southwestern horizon. It's also good to start viewing Saturn as twilight deepens and it still lies high in the sky. Third, if you have a reflector, be sure it's perfectly collimated. And finally, let your telescope cool down to the same temperature as its surroundings before you ask it to present a high-contrast image of Saturn.

Viewing marginal planetary detail like this calls for patience. You may have to view Saturn for several minutes to catch that 5- or 10-second window of good seeing. So get comfortable and prepare to enjoy the view when it comes.

The series of satellite events taking place as the Sun and Earth pass through Saturn's ring-plane continues strong this month. See "Spotlight on Saturn's Satellites" (September 1995) for a complete "backgrounder" on these fascinating events. December's highlights for observers in North America are repeated in the table below. — *R.S.*

EVENTS OF THE SATURNIAN SATELLITES

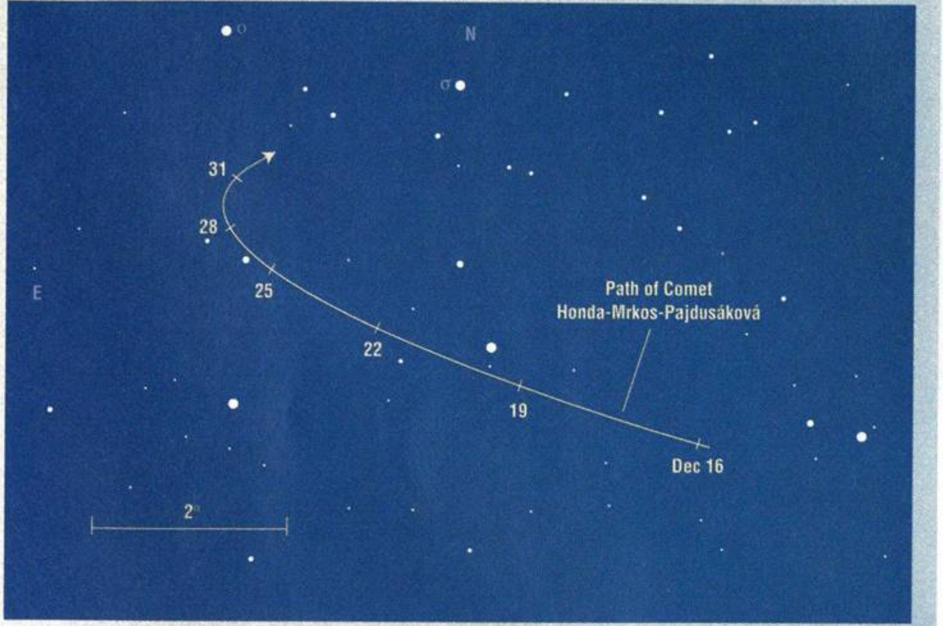
Date	**Begin Time**	**End Time**	**Event**	**Type of Event**	**Light Loss**	**Distance**
December 2	8h48.6m	8h50.5m	Saturn eclipses Dione	Reappearance	—	1.6
December 4	8h53.6m	9h08.7m	Saturn eclipses Titan	Reappearance	—	2.9
December 4	8h54.2m	9h03.5m	Dione eclipses Rhea	Annular	54%	5.7
December 5	0h39.0m	0h42.0m	Saturn eclipses Rhea	Reappearance	—	1.8
December 5	2h31.1m	2h32.9m	Saturn eclipses Dione	Reappearance	—	1.6
December 7	6h34.4m	6h35.7m	Tethys eclipses Mimas	Partial	23%	2.4
December 9	3h51.4m	3h52.7m	Tethys eclipses Mimas	Partial	21%	2.4
December 11	1h08.5m	1h09.9m	Tethys eclipses Mimas	Partial	12%	2.3
December 11	3h39.5m	3h45.2m	Rhea eclipses Dione	Partial	31%	6.3
December 12	22h25.5m	22h26.9m	Tethys eclipses Mimas	Partial	12%	2.3
December 13	7h38.3m	7h40.1m	Saturn eclipses Dione	Reappearance	—	1.6
December 14	1h35.2m	1h38.3m	Saturn eclipses Rhea	Reappearance	—	1.8
December 16	0h59.9m	1h02.5m	Rhea eclipses Mimas	Partial	98%	2.6
December 16	1h20.6m	1h22.5m	Saturn eclipses Dione	Reappearance	—	1.6
December 20	8h03.1m	8h18.6m	Saturn eclipses Titan	Reappearance	—	2.8
December 23	2h31.6m	2h34.7m	Saturn eclipses Rhea	Reappearance	—	1.8
December 25	7h13.7m	7h16.0m	Dione eclipses Tethys	Partial	12%	3.9
December 26	3h24.7m	3h26.0m	Tethys eclipses Mimas	Partial	5%	2.2
December 28	0h41.7m	0h43.0m	Tethys eclipses Mimas	Partial	5%	2.1

Begin Time: Universal time at beginning of event. (Subtract 5 hours to convert to EST, 6 hours for CST, 7 hours for MST, and 8 hours for PST.) **End Time:** Universal time at end of event. **Event:** The nature of the event and the objects involved. **Type of Event:** Whether the event is partial, total, or annular, or a disappearance or reappearance. **Light Loss:** The percent of light lost by the eclipsed satellite at midevent. **Distance:** The apparent distance of the satellite from Saturn's center expressed in Saturnian equatorial radii.

A Comet for Winter Evenings

Periodic Comet Honda-Mrkos-Pajdusáková offers telescope owners a nice evening apparition this month. Because it is approaching both the Sun and Earth, it brightens rapidly, from roughly 11th magnitude at the beginning of December to about 7th magnitude at month's end.

As with many comets, however, there's an important catch. Although Comet H-M-P nears the Sun as the month progresses, it also approaches the twilight horizon. Viewing the comet requires that you find an observing site with an unobstructed and dark horizon toward the southwest. Begin your search with binoculars or a finderscope starting about an hour after sunset.



To make the effort more challenging, Venus lies near the comet for most of the month, passing just a quarter degree north of it on the 24th. At magnitude –4.0, Venus shines so brightly that it easily could keep you from seeing the comet. If you want to observe H-M-P around the 24th, be sure to keep Venus out of your telescope's field of view and don't even look at it with your naked eye or you'll risk losing dark adaption. After mid-January, the comet moves into the morning sky and climbs quickly into a dark sky.

Because comet brightnesses are notoriously difficult to predict, you might try estimating H-M-P's magnitude. All you need to do is select several stars about as bright as the comet's expected magnitude, then throw each of them out of focus until they resemble the comet's in-focus image. The star that most resembles H-M-P when out-of-focus is closest to it in magnitude.

Finally, this comet ranks as one of the brighter comets in recent years, a situation that makes it a good target for astrophotographers. If you own a 35mm camera, I recommend using a 400- to 600mm telephoto lens to get the best images. You can sharpen the image significantly by stopping the lens down a bit. — *R.S.*

COORDINATES FOR COMET HONDA-MRKOS-PAJDUSÁKOVÁ

Date	**R.A. (2000)**	**Dec.**
December 16	20h09.1m	–22°44'
December 19	20h16.5m	–22°12'
December 22	20h22.6m	–21°40'
December 25	20h27.1m	–21°07'
December 28	20h29.5m	–20°34'
December 31	20h29.5m	–20°03'

naked-eye vision. It passes 2° south of **Neptune** on December 16 and 1.3° south of **Uranus** on December 20. Neither of these outer planets is bright enough to shine through the twilight glow, so only those who are enthusiastic about seeing conjunctions will focus their binoculars or telescopes on them. Before the month ends, both Uranus and Neptune drop into the Sun's glare.

Easily the prettiest conjunction for Venus this month comes on the evening of December 23, when the young crescent Moon passes nearby. The crescent also appears striking above Venus during twilight on Christmas Eve. If you want to become an instant hero to your assembled family and friends, take them outside to look.

One final planet appears in the evening sky, although it lies well away from the western twilight. **Saturn** stands almost due south as darkness falls, among the background stars of the constellation Aquarius. At magnitude 1.1, it has now dimmed considerably from its summer and autumn peak.

Saturn's famed rings are all but invisible now because we see them nearly edge-on. Actually, Earth lies slightly north of the planet's rings and the Sun slightly south, so the view through a telescope is of backlit rings. The third and last time that Earth will pass through the ring-plane during this current series comes on February 11, 1996, and shortly afterward Saturn will disappear into the Sun's glare. Then as winter blossoms into spring for the Northern Hemisphere, Saturn will emerge into the predawn sky, with its rings opening back into view. □

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. Rick Shaffer is an engineer and writer living in Arizona.

Test-driving
Celestron's Apo Refractor

Optical design combines with special glass to produce a short refractor that provides crisp, error-free images. And the price tag includes an equatorial mount as well.

by John Shibley

Commercial telescope makers pride themselves on being a source of good, affordable optics. That philosophy plays out through the ubiquitous Schmidt-Cassegrain telescope (SCT), which thousands of amateur astronomers have chosen as a gateway into popular astronomy.

But an SCT isn't the only way to crack the astronomical nut; refractors offer significant advantages for certain types of observing and photography. Acknowledging that reality, Celestron's president Alan Hale feels it's important to include the classical refractor in his company's product line. Specifically, one that offers a respectable 4-inch aperture and focal ratio (f/9) to yield adequate magnification, some photographic flexibility, and sufficient portability.

Celestron's GP-C102ED is intended to fill that bill.

A Long-lost Love, Recovered

Astronomers have always had a love/hate relationship with the refractor. They love the design because it lets light pass through the scope unobstructed for maximum contrast. This is not the case with reflectors like Newtonians and SCTs, where a secondary mirror, which directs light into the eyepiece, obstructs part of the light path. This so-called "secondary obstruction" lowers contrast in an image.

The hate part has something to do with the interplay between glass and light.

All telescopes grab light and focus it to a point, near which you place an eyepiece to magnify an image. Reflectors do this with mirrors that bounce light off a curved surface. Refractors accomplish the same by having light pass through a glass lens and exit at an angle. Grind the lens a certain way and all those exit angles focus to a single point. Right? Well, it's not quite that simple.

White light is an amalgam of all colors, each of which exits the lens at a slightly different angle. This means that each color comes to a different focal point, and the resulting image (from a simple, one-element lens) is both unsharp and full of stray color. The problem is called chromatic aberration.

The solution, discovered about two centuries ago, is to place a second lens (with different glass properties) next to the first lens. The second lens brings virtually all the stray colors back to a common focus, and the resulting two-element lens is called an achromat, meaning "uncolored."

But achromatic lenses don't correct every last bit of color. In addition, their small amount of residual color becomes more noticeable in the shorter focal ratios that observers and astrophotographers want most. The solution lay in picking a lens element to bring the last of the errant color back into the image. The result is called the apochromat lens, which means "without color."

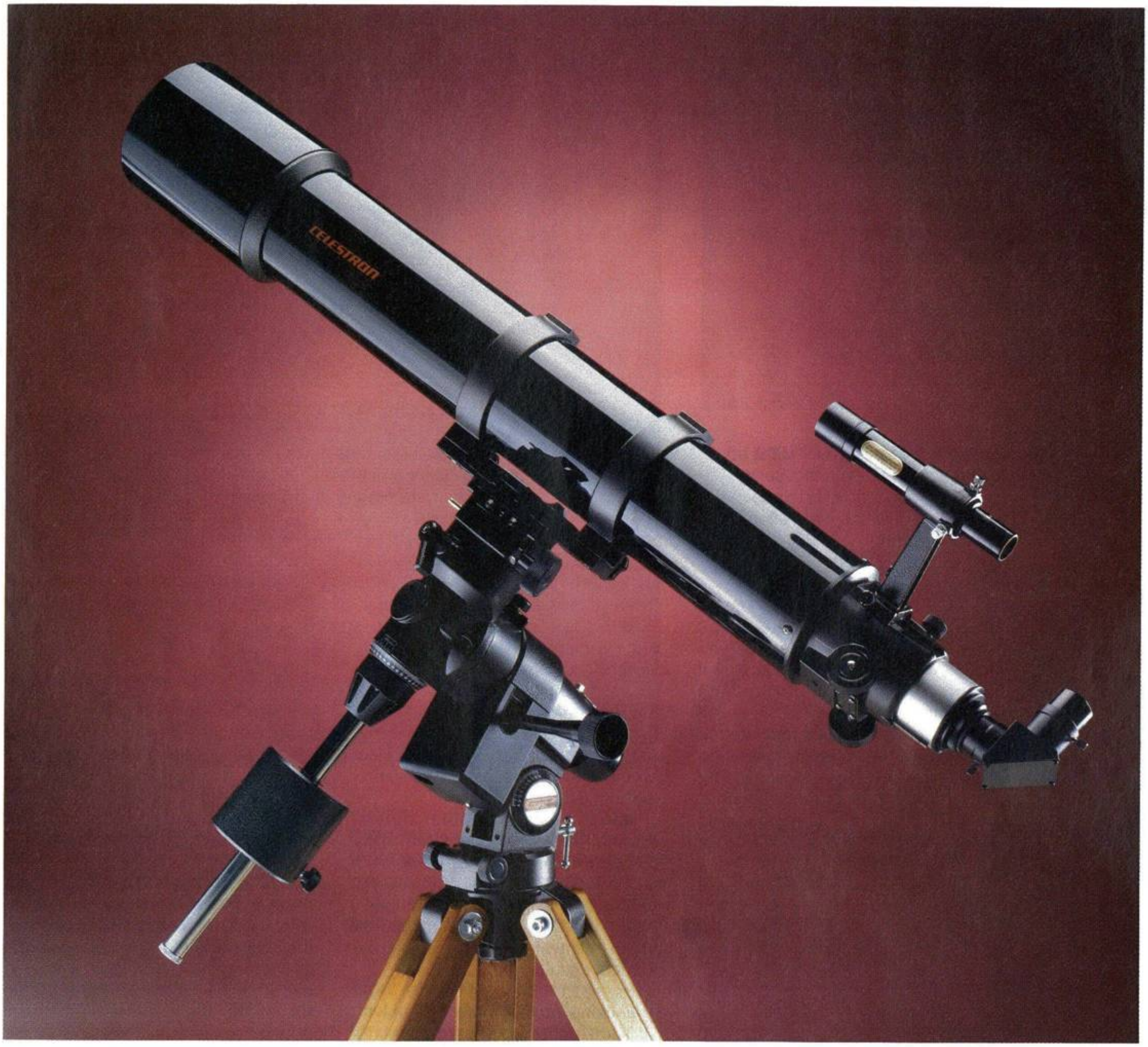
THE NORTH CELESTIAL POLE becomes an easy target thanks to an illuminated finder built into the polar axis. The silver screw adjusts the latitude of the axis.

The "apo" lens element is made from either fluorite glass or ED (extra-low dispersion) glass. On paper at least, fluorite glass might afford slightly better results, but ED glass runs so close a second that few observers could tell the difference without being told. And there's a practical reason why most "apo" refractors use ED glass — cost. ED glass is cheaper and easier to work with; fluorite is costlier at the outset and due to brittleness, wastages of up to 40 percent during manufacturing are not uncommon. (Some makers use a combination of fluorite and ED glass elements, or use fluorite exclusively, depending on design philosophy or what their customers prefer.)

However designed, the apochromatic refractor has made a real splash in the market. After all, they provide many benefits: observers like their wide fields of view and easier portability, while astrophotographers like their image brightness and photographic speed. Both groups like the typical sharp images and high contrast the apochromatic refractor provides.

Celestron's Apo Answer

The GP-C102ED's optics are of two elements (a doublet) made with extra-low dispersion (ED) glass. Doublet achromats have historically shown some residual chromatic aberration, which reveals itself as a blue or violet fringe that surrounds an image in sharp focus. The fringing becomes most noticeable on bright stars, planets, and the Moon.



All photos, ASTRONOMY: Chris Becker

UNDER THIS SLEEK BLACK finish lies an exceptional optical performer. A 4-inch apochromatic refractor and the Great Polaris mount team up to make the GP-C102ED.

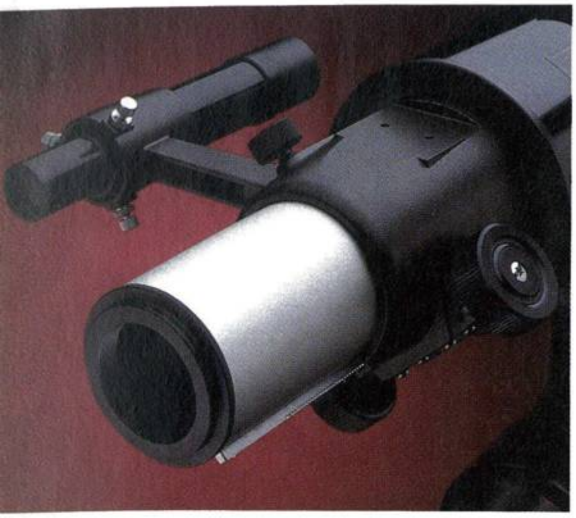
Until this year, Celestron marketed a doublet refractor that had a crown glass primary element coupled to a fluorite secondary element to reduce residual color. According to Hale, the GP-C102ED uses ED glass exclusively to yield better performance at a cheaper price.

To see if Celestron's use of ED glass eliminated the residual colors, I tested the GP-C102ED's optics at 100x by looking at Spica and the Moon's bright, sunlit limb. In both instances, sharply-focused images showed no colored fringes, even with a jump to 200x. While looking at bright Vega, I detected some very slight blue fringing that seemed to come and go as the atmosphere's steadiness varied.

The bright Moon also comes in handy for evaluating how a telescope handles extreme glare. I did this for the GP-C102ED by positioning a waxing gibbous Moon just out of the field of view. Though there were a few stray flashes of glare as I pivoted the tube away from and toward the Moon, all in all the system seemed to have glare under control.

Celestron does this by multi-coating all lens surfaces, which reduces the amount of glare generated by light passing through the objective. The tube's interior is lined with at least two sets of baffles painted flat black, as is the tube's entire interior. The paint, combined with baffling, squelches internal reflections before they have a chance to reach the eyepiece.

Such control of stray light translates into excellent contrast when observing the Moon, the planets, and deep-sky objects. Increased contrast has been the traditional allure of refractors. Observers love the design because light passes unobstructed from the objective to the eyepiece to yield maximum contrast. An optically well-crafted refractor such as the GP-

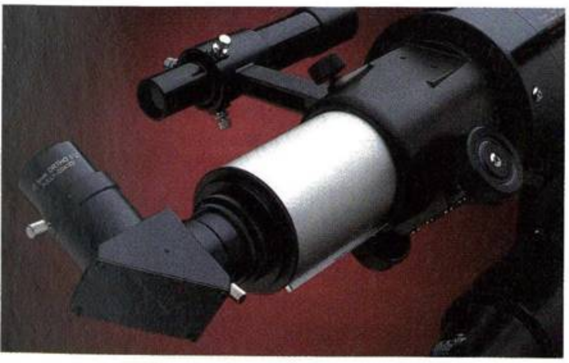


A BEEFY 2½-INCH TUBE adds to the rack-and-pinion focuser's overall rigidity. It rides on three tracks, one of which has Teflon for smooth focusing.

THERE'S ROOM ENOUGH for piggyback accessories. Holes in the tube rings accept standard rings for a photo guidescope. The two holes on the rear cell are for a piggyback camera adapter that Celestron might sell in the future.

C102ED offers the advantage of "clear aperture," a characteristic especially coveted by observers who look for delicate surface shadings and transient atmospheric features on other planets.

But other aberrations unrelated to color may lurk. Spherical aberration happens when light rays passing through the center of a lens focus at a different spot than rays passing through its outer edge. I looked for this in the GP-C102ED by throwing the image of a bright star slightly out of focus and letting it blossom into an array of concentric circles or rings. This is called a diffraction pattern, produced by the wave nature of light and its interaction with the objective lens.



THE REFRACTOR COMES EQUIPPED with a 12.5mm Orthoscopic eyepiece and a 1¼-inch star diagonal. A 6x30 finderscope mounts in an extra-tall bracket that detaches for easy storage.

If a refractor suffers from spherical aberration, examining the image just inside of focus reveals that the diffraction pattern's outermost ring is brighter than its innermost ring. Conversely, looking just outside of focus shows an inner ring that is brighter than the outer diffraction ring. In the GP-C102ED's case, ring spacing, brightness and clarity was identical on either side of focus, a sure sign of sterling optics.

Astigmatism is another optical downfall for any scope. A normally pinpoint star image takes the form of an ellipse that alternately flips over at right angles on either side of focus. Again, the Celestron refractor proved up to the test, yielding perfectly-formed, circular images.

Looking into the Tube Assembly

These optics are housed in an aluminum tube that measures 39 inches from the tip of its 6½-inch removable aluminum dew cap to the end of the star diagonal, with the focuser racked all the way in. A coat of durable black enamel covers the tube. An aluminum lens cap slips over the front element to protect the optics during storage. The cap has a one-inch removable plug to make removing the lens cap easier.

Celestron includes a 6x30 finder that slides and locks into a dovetail track on the telescope tube's rear cell. A bracket elevates the finder about five inches above the refractor tube, making it easy to look through without bumping your chin on the telescope.

While a 6x30 finder is more than adequate for sighting the Moon, planets, and bright stars, you should consider upgrading to at least an 8x50 finder before going for faint deep-sky targets.

I found the GP-C102ED's rack-and-pinion focuser most impressive. At its heart is a beefy, 2½-inch aluminum barrel that glides along three tracks, one of which has a Teflon pad, inside the rear cell. The focuser has an adequate travel distance of 3¼ inches, and can be locked into place with a hand-tightened knob to eliminate the risk of slipping.

Threaded surfaces inside the focuser barrel accept a variety of rings and adapters that let you use the scope photographically or visually. One adapter receives 1¼-inch eyepieces (and the included star diagonal), while still another takes 2-inch eyepieces.

Celestron also provides two extension tubes for projection photography and straight-through viewing. An optional adapter (Item # 93634, $76) connects a 35mm camera to the scope at prime focus. All these items fit into a plastic storage container the company provides.

The optical tube assembly locks into a pair of aluminum tube rings lined with felt. Hand-tightened knobs loosen to rotate the tube or slide it back and forth during balancing. These rings merge with a dovetail plate that attaches to the telescope's equatorial mount.

Sizing Up The Rest

Celestron's GP-C102ED comes with the Great Polaris mount, manufactured by the Japanese telescope

GP-C102ED STANDARD SPECIFICATIONS

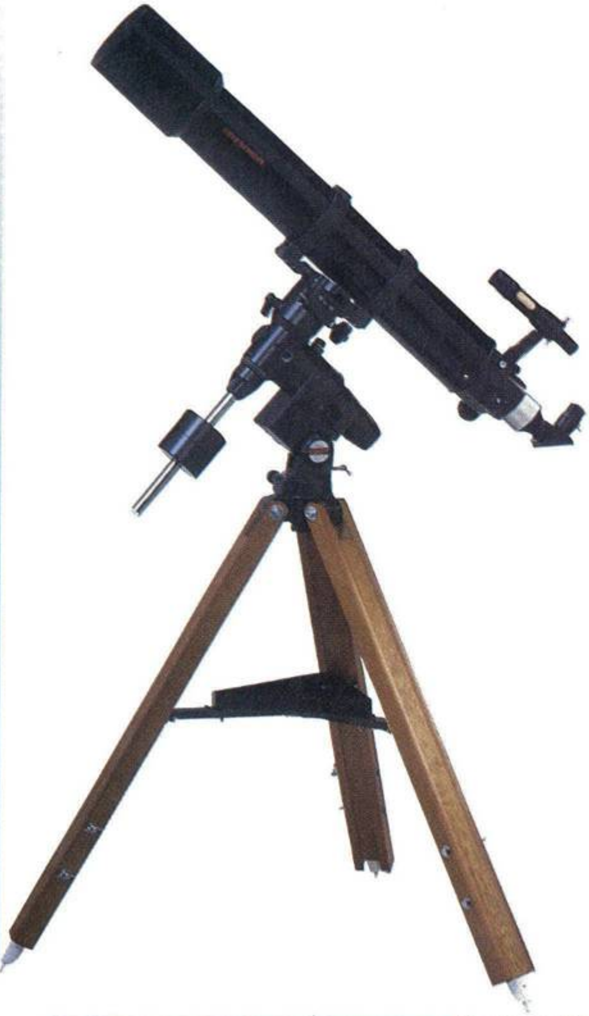
Aperture:	4.1 inches (102 mm)
Focal ratio:	f/9
Focal length:	918mm
Length of tube:	36 inches
Size of focuser:	2-inch
Included 1.25-inch eyepiece:	12.5 mm (Orthoscopic, 78x)
Photographic field:	2.25° x 1.50°
Weight of tube assembly:	9 lbs.
Weight of tube and GP mount:	36 lbs.
Height to bottom of equatorial head, tripod legs extended:	45 inches
Height to bottom of equatorial head, legs retracted:	29 inches
Warranty:	limited lifetime (optics), one year on everything else
Suggested list price:	$4,598 (Includes accessory tray, accessory container, tube cap, 1¼-inch eyepiece adapter, star diagonal, 12.5 mm Orthoscopic eyepiece, and 6x30 finder.)

OPTIONAL ACCESSORIES

(Suggested list prices; actual prices vary with dealer)

Great Polaris motor, dec. drive, and control panel:	$590
2-inch eyepiece adapter:	$60

Also available: Advanced Astro Master digital setting circles, photographic tele-extender tube, T-adapter, GP half pier, and vibration suppression pads. Celestron, 2835 Columbia Street, Torrance, CA 90503, (310) 328-9560.

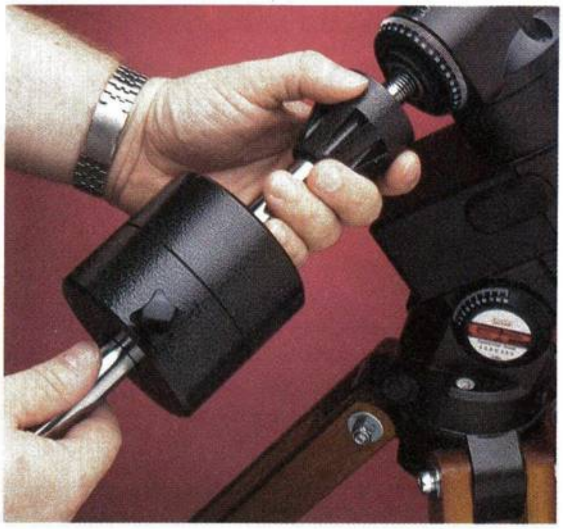


maker Vixen and marketed around the world by Celestron. The GP mount has a German equatorial head mated to a set of extendible wooden tripod legs. Although ASTRONOMY has previously reviewed the Great Polaris mount (see "Celestron's Compact Newtonian," December 1994), a few features and observations are worth mentioning again.

For polar alignment, the GP's latitude adjustment includes a printed scale that reads between 15° and 65° in 2° increments. For more precise alignment, a finder scope with a lighted reticle built into the polar axis lets you precisely locate the north celestial pole. Fine adjustment knobs and screws slowly elevate the polar axis and pivot the mount in azimuth until the pole is centered.

Once the mount is even roughly aligned, you can manually follow objects in the eyepiece by using oversized knobs to adjust the right ascension and declination axis. The GP mount doesn't come with a clock drive, but a kit that also includes a declination drive and a control paddle is available.

Moving the telescope in right ascension at high power using the slow motion controls was my only frustration when using the GP-C102ED/GP combo. When viewing at greater than 300x, I found vibrations in the mount took upwards of 10 seconds to dampen out. A combination of tube length and hanging a moderately heavy eyepiece on one end creates this long-lasting vibration. Panning around a field of view at high power will almost require that you purchase the clock drive package with its slewing options.



THE MOUNT SHEDS 15 POUNDS when the counterweight bar assembly unscrews from the equatorial head. This lightens your load during transport.

Given its price, though, the mount offered exceptional portability and smooth operation. Its 4-foot height when fully extended is useful for viewing objects close to the horizon or observing straight-through without a star diagonal.

Other refractor/equatorial mount combinations on the market may outperform the GP-C102ED package, but they are considerably more expensive. For the most part, refractors don't come cheap because the optics are more expensive to make. Price aside, there are compelling reasons to consider a refractor, such as portability, exceptional contrast, and wide fields of view. The GP-C102ED goes the extra mile to provide all of this on a mount that's up to the job. □

The Secrets of Orion's Great Nebula

Filters help you see the most you can in the sky's greatest showpiece nebula.

by Alister Ling

The Orion Nebula (M42) is number one in the hearts of observers scattered across the Northern Hemisphere. A huge cloud of gas and dust spanning dozens of light-years, the eerie, glowing object is visible to the naked eye on any clear winter night. Binoculars reveal bright stars embedded in a fuzzy, green glow: these are some of the stars that are forming out of the Orion Nebula's gas. This giant star factory, as becomes apparent with a telescope of just 4 or 6 inches, is churning out baby suns like there's no tomorrow.

The unusual complexity of the Orion Nebula attracts nearly every backyard observer. The swirls of gas and dust studded with stars are breathtaking from country skies. Yet I recently experienced the Orion Nebula in a whole new way that opened my eyes to new and satisfying views. I discovered that filters do more than enhance the glow and extend it farther out — they actually highlight new shapes and boundaries.

The unusual complexity of the Orion Nebula attracts nearly every backyard observer.

A New View of M42

Let's go on a tour of the Orion Nebula. We'll compare the filterless views in natural light to those through Oxygen III (O III) and Hydrogen-beta (H-β) filters (see box on page 81). These filters are produced by Lumicon in California and are advertised routinely in the pages of ASTRONOMY. They produce views dramatically different than other through deep-sky filters I have used.

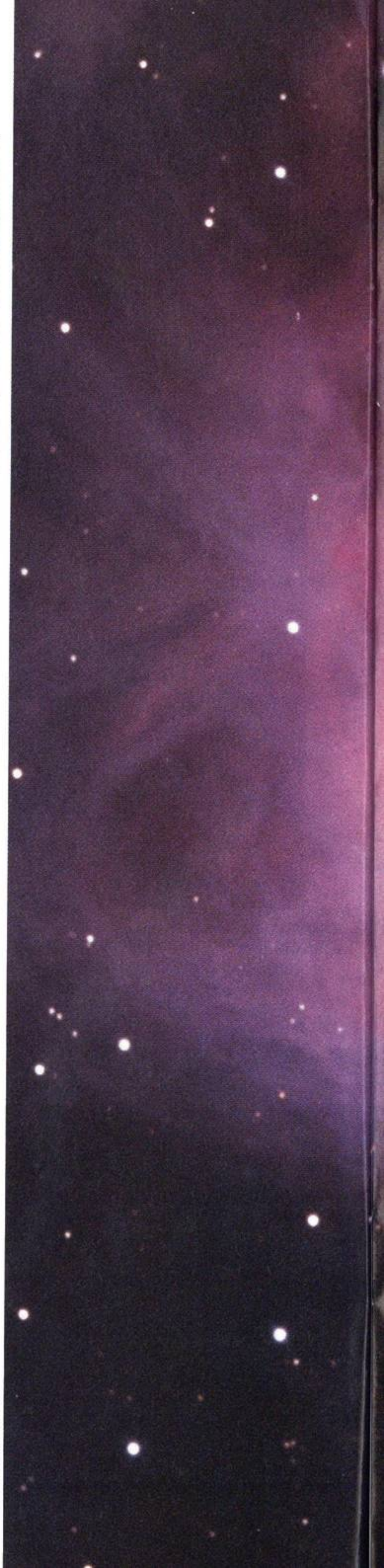
You can compare the views with the beautiful photograph at right. Its color balance is one of the best I've seen. The red areas show up best through the H-β filter while the green ones are well-defined in the O III.

The details I'm describing come from observations made with a 12.5-inch Dobsonian under "average" skies. With fresh snow on the ground reflecting lights, the sky was bright enough to hide the Horsehead Nebula, which is usually visible (with an H-β filter) from our country site. In other words, an 8-inch scope under good conditions should be able to show as much detail as I describe, if not more.

The Central Region

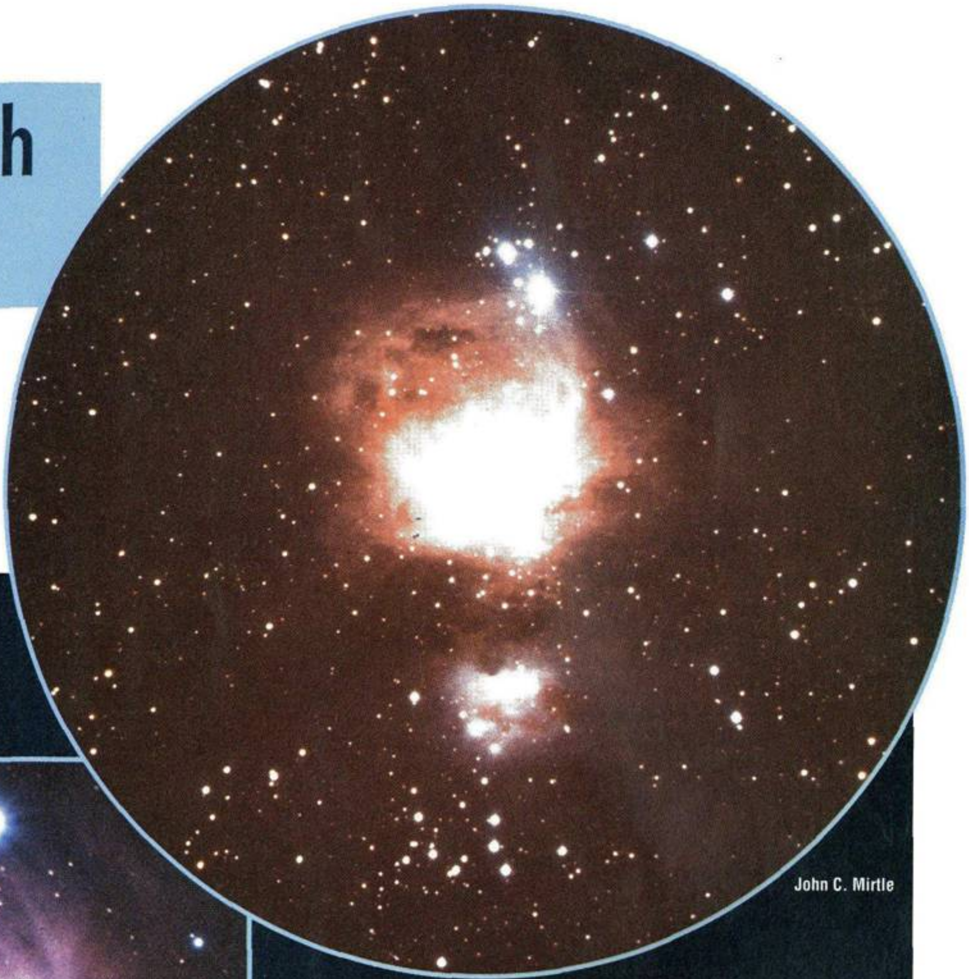
The most striking visual characteristic of M42's heart is its strong green color. Blazing with a fire that no picture can reproduce, the four bright stars of the Trapezium are a magnificent sight. The brightest area of nebulosity is roughly square-shaped with a dark intrusion on the north side — some call this the Fish's Mouth. (See the sketch on page 82.)

Heading south into the main fan is what I call the "thrust," a bright area attached to the central square. To see

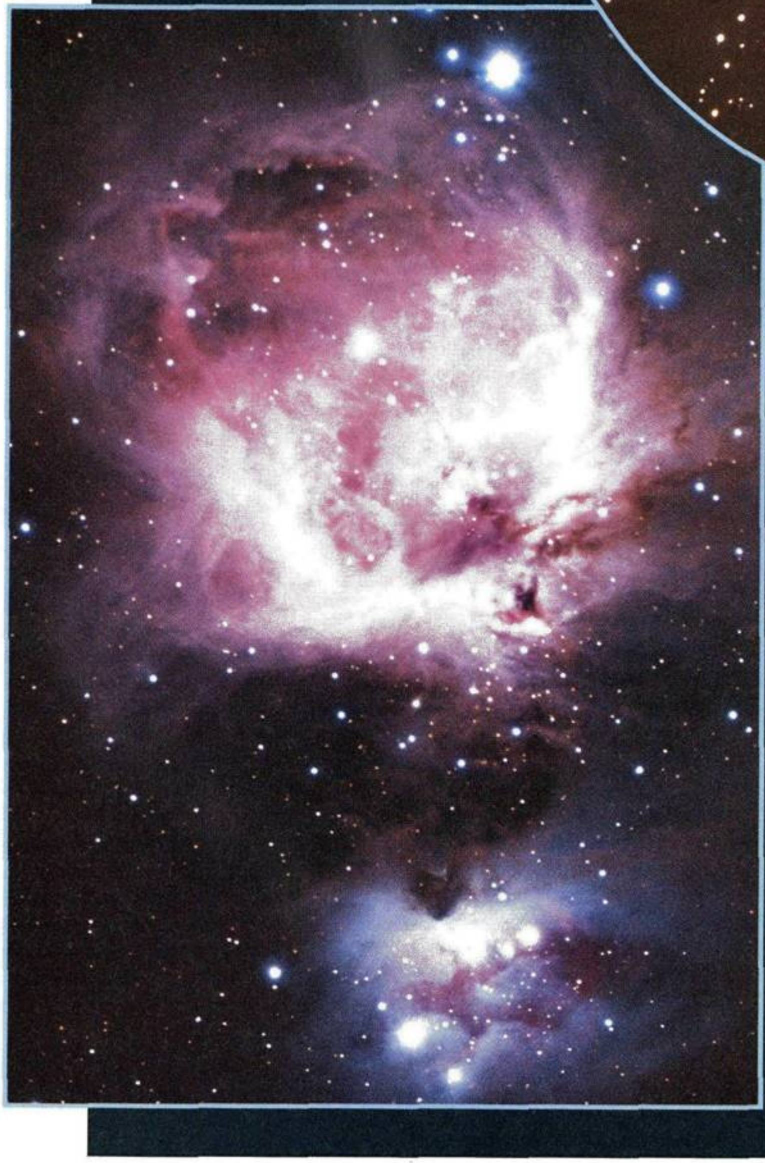


Bill and Sally Fletcher

The Depth of Orion

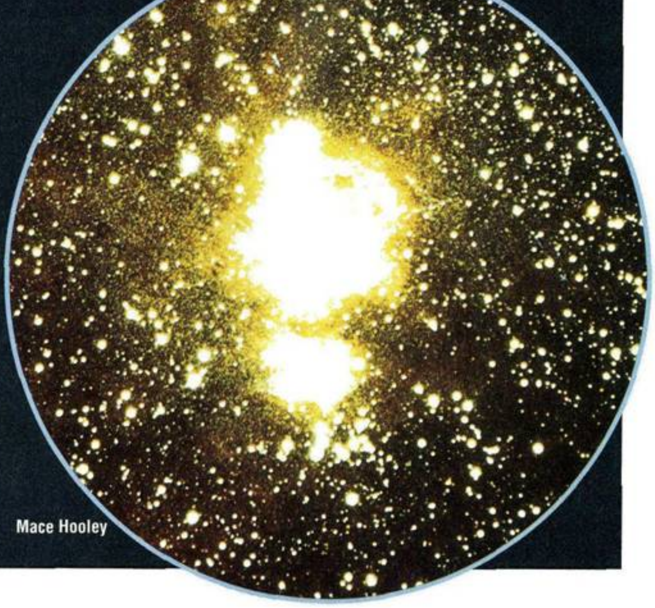


John C. Mirtle



Jason Ware

THE ORION NEBULA presents a rich and varied network of nebulosity as revealed in a long-exposure color photograph. Many of the wispy details are visible to the eye alone. An even longer exposure (above) reveals a central cloud saturated with brightness and faint, outer arcs of nebulosity. An even deeper exposure (below) reveals the whole region is enshrouded in nebulosity.



Mace Hooley

color in this bright area, you must use direct vision because the center of your retina contains the most color receptors. Observers more fortunate than me will detect pinkish and bluish colors along the wings, the arcs of light streaming away from M42's core, but I was only able to detect a green color in the core and thrust areas.

As you stare at the core it becomes incredibly mottled. There are all sorts of darker areas and filament-like brighter pieces. Switch to medium and even high powers to get a better look — you'll be amazed. Before you use the filters here, check out the unfiltered view.

The Oxygen III Filter

Attach an O III filter and M42 changes significantly. At 65x, nebulosity floods the view. Faint areas that were invisible are now obvious. The greatest change occurs along the bright wing to the east. So razor sharp is the inside edge that I call it "the sword." It continues past a bright star, though it becomes somewhat fainter at that point.

Without the O III filter, nebulosity does not appear to extend past the star.The sword's edge dulls, as its brightness takes only a moderate drop toward the interior of M42.

Surveying the eastern side with the O III filter, the eye notices a prominent notch of darkness where the sword curves away from a straight line of nebulosity. Both in natural light and through the H-β filter, this notch fills in with nebulosity.

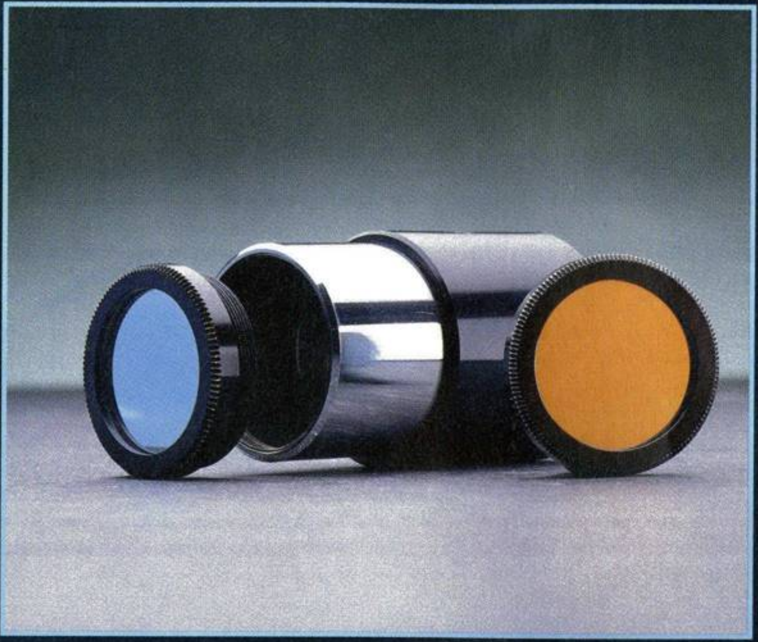
The fainter, western wing of M42 appears bright in the O III filter, as does the thrust that brightens and pushes well out into the fan region. The whole area between the western wing and the thrust fills in with a uniform glow, but oddly there is little change between the thrust and the sword. This must by why the sword is so prominent in the O III view.

The H-β Filter

The H-β filter added contrast and changed forever the way I see the Orion Nebula. I was shocked to see a "sail" to the west, parallel to the three bright stars along the central thrust. Brightness-wise, the sail is detached from the background nebulosity. Even with a 4.5-inch reflector, the sail is obvious with the H-β filter.

Overall, the appearance of the fan region is very uniform, rounder than others parts of the nebula (except for the sail section), both east and west. It's quite different in comparison to the appearance through the O III fil-

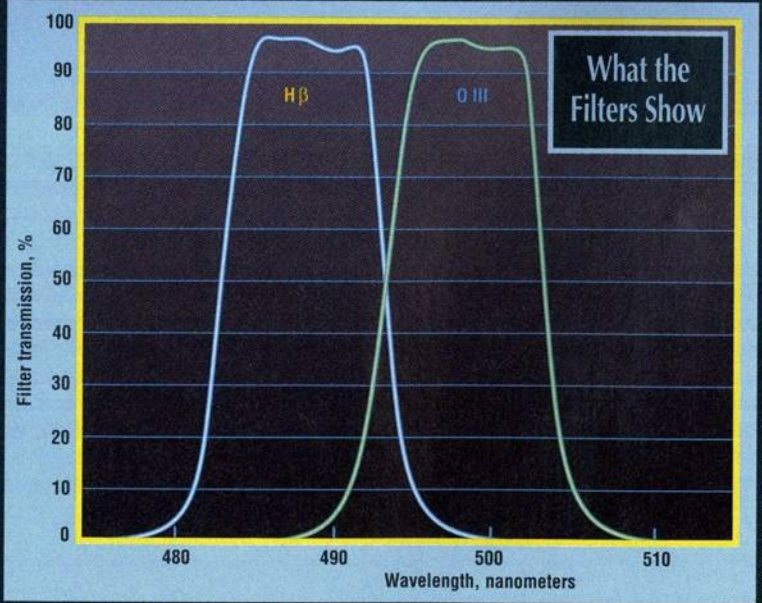
A Little Oxygen, a Little Hydrogen



ASTRONOMY: Chris Becker

Clouds of gas in the Galaxy like the Orion Nebula emit a broad spectrum of light, but much of it is concentrated in several narrow areas. Two significant such areas are the O III and Hβ lines, which occur at about 500 nm and 486 nm, and account for about ¼ and 1/15 of the nebula's visible light, respectively. The greenish light of O III results from doubly-ionized oxygen, the bluish light of Hβ from hydrogen.

The fact that these narrow bands pack so much of the nebula's light allows filtering out light pollution and concentrating on these bright portions of the nebula's light. Lumicon's O III and Hβ filters (direction, shown with an eyepiece), are threaded to screw into a standard 1¼" eyepiece and permit this selective observing of important nebular wavelengths.

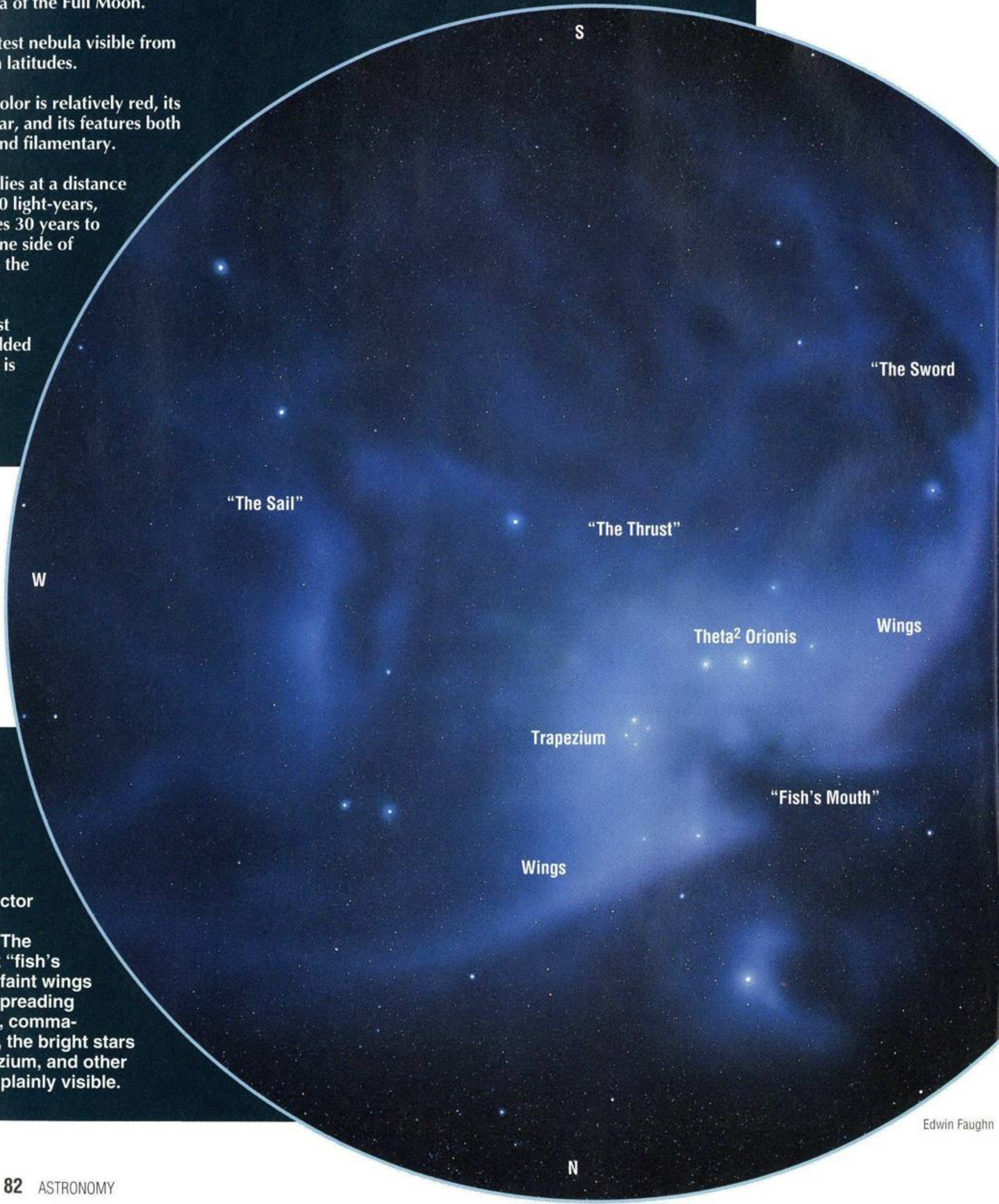


ASTRONOMY: Thomas L. Hunt

The Orion Nebula

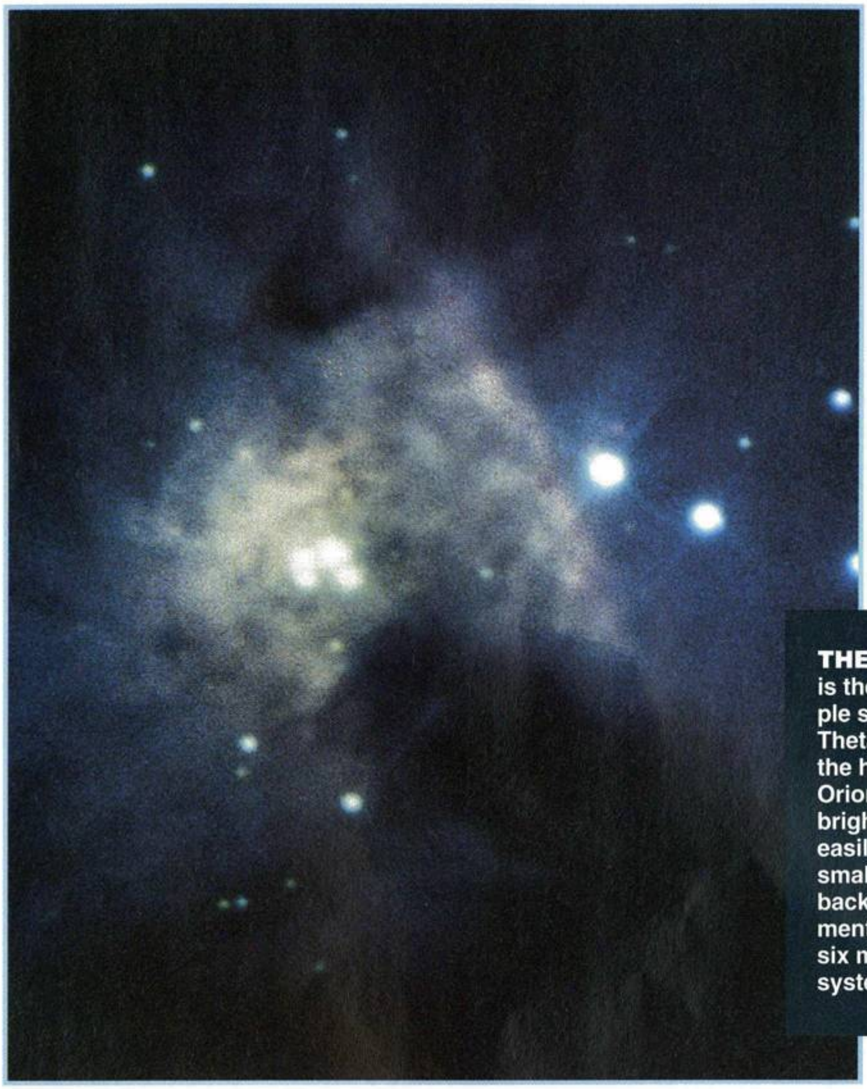
The Orion Nebula (M42, NGC 1976)

- Consists of gas glowing by emitting its own light and reflecting light scattered onto it from nearby bright stars.
- Measures 66' by 60' in diameter, more than four times the area of the Full Moon.
- Is the brightest nebula visible from mid-northern latitudes.
- Its overall color is relatively red, its shape irregular, and its features both amorphous and filamentary.
- The nebula lies at a distance of some 1,600 light-years, and light takes 30 years to travel from one side of the nebula to the other.
- The brightest object embedded in the nebula is a 3rd-magnitude O-type star.



A LARGE SCOPE VIEW of the Orion Nebula like this sketch made with a 20-inch reflector shows the major areas. The central, dark "fish's mouth," the faint wings of material spreading away from it, comma-shaped M43, the bright stars of the Trapezium, and other features are plainly visible.

Edwin Faughn



Jim Baumgardt

THE TRAPEZIUM is the bright multiple star, also called Theta^1 Orionis, in the heart of the Orion Nebula. Four bright stars are easily visible in small scopes; large backyard instruments can reveal six members of this system.

ter. This symmetry is also seen in visible light, though not as prominently.

The eastern arc with its sword, while distinct in natural light, is less so with the H-β. What a change from the O III's razor sharp outline. The thrust is much less noticeable as well.

M43, a Little Companion

For years this interesting cloud of dust and gas was just a nebular blob to the north of M42. There's nothing like some close attention and a filter to change one's perspective.

M43's overall shape reminds me of a comma, its tail section lying on the north side. Until now, I had never noticed a gap in the nebula where the tail joins the circular section. With the O III filter, the entire cloud practically disappears — I needed strong averted vision to see anything! The comma tail was invisible.

The H-β view surprised me again, because it is usually darker than the O III. Not only was the comma tail visible, but the gap was filled in with nebulosity. I was delighted that the color picture shows a lot of reddish light in the gap. The other amazing thing about M43 is the sharpness of its eastern boundary. In short, the H-β filter really enhances the tail of the comma cloud.

A Revelation?

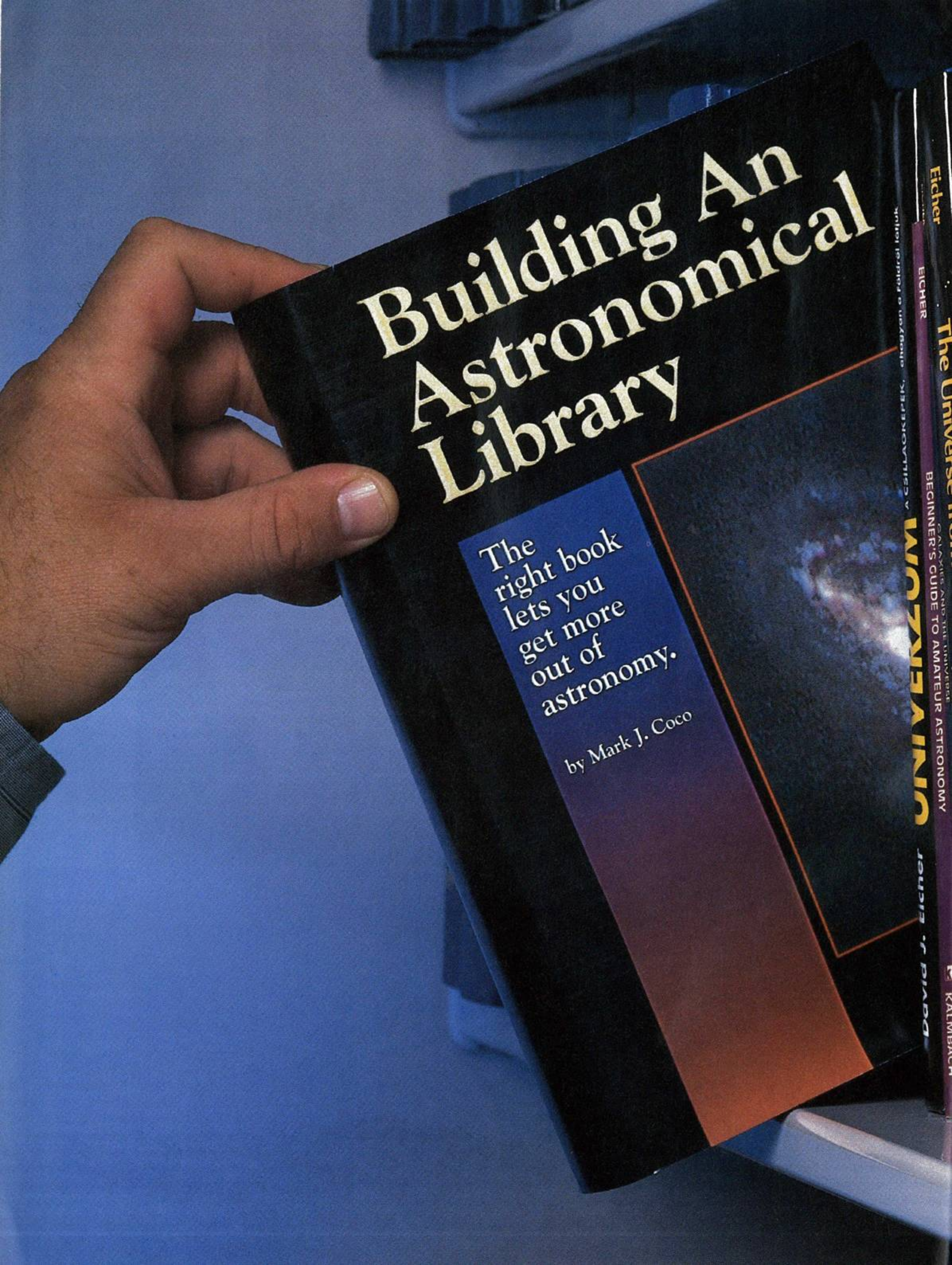
Each filter highlights a different physical structure within the huge gas cloud. My observations show that the greens and reds in the picture correspond remarkably well to the views through the O III and H-β filters.

It has to be made quite clear that I never saw red nebulosity. Everyone is used to seeing red in pictures because that is the color of H-α, which is a much stronger emission than the associated H-β. Unfortunately, the human eye just cannot detect red at low light levels, but it can see H-β because it is green. A reasonable assumption is that wherever there is strong H-α emission, the H-β emission will also be fairly strong.

Other kinds of deep-sky filters will produce similar but different results with the Orion Nebula. I can't say for sure what your type of filter might reveal. It will definitely enhance the clouds of gas and show tendrils of nebulosity that escaped your unfiltered eye. Light-pollution filters, including the Lumicon's UHC and Orion's Ultrablock, include both the H-β and O III emission lines. Some of the differences I've pointed out will not be as noticeable. Only the O III and H-β filters isolate the lines.

Spend some time with your filters observing the Lagoon (M8), the Omega (M17), and Eagle (M16) and if you live far enough south, Eta Carinae. Like the Orion Nebula, fascinating structures are yours to uncloak. Check them out! □

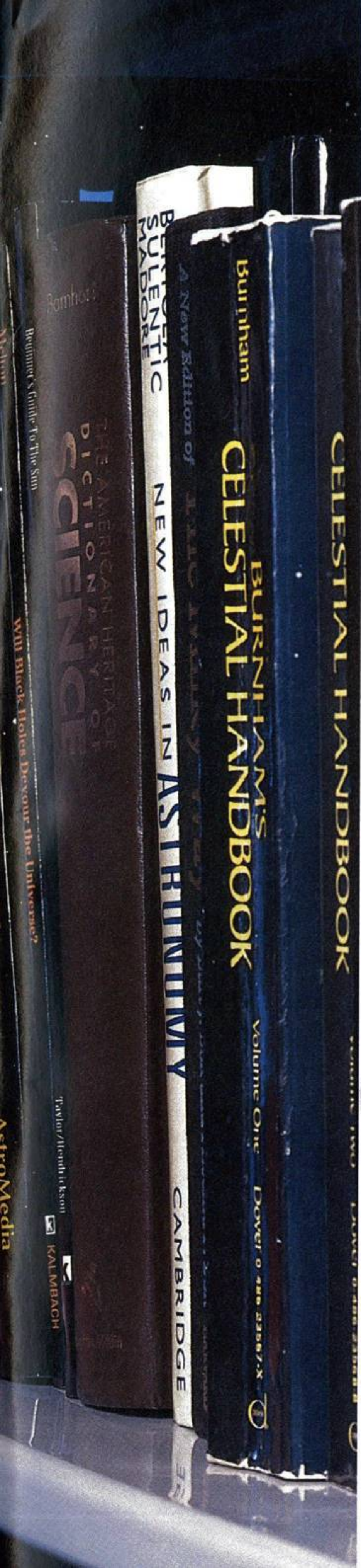
Alister Ling is a meteorologist with Environment Canada and a regular contributor to ASTRONOMY.


Eicher
The Universe
EICHER
GALAXIES AND THE UNIVERSE
BEGINNER'S GUIDE TO AMATEUR ASTRONOMY
KALMBACH
UNIVERZUM
A CSILLAGKÉPEK, ahogyan a Földről látjuk
David J. Eicher

Building An Astronomical Library

The right book lets you get more out of astronomy.

by Mark J. Coco

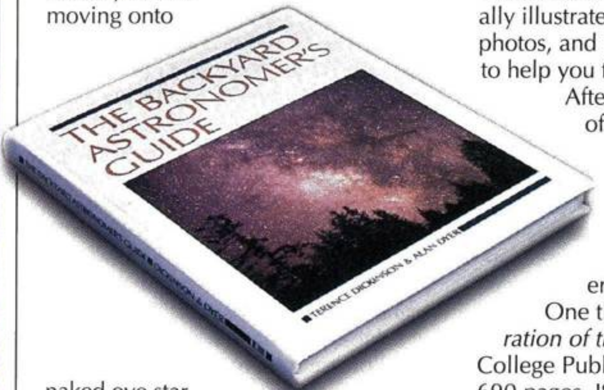

Bernhard
Beginner's Guide To The Sun
Will Black Holes Devour the Universe?
Taylor/Hendrickson
KALMBACH
THE AMERICAN HERITAGE DICTIONARY OF SCIENCE
BERTOLA SULENTIC MADORE
NEW IDEAS IN ASTRONOMY
CAMBRIDGE
A New Edition of
Burnham
BURNHAM'S CELESTIAL HANDBOOK
Volume One
Dover
CELESTIAL HANDBOOK
AstroMedia

Say "astronomical accessories" and what usually comes to mind are flashlights, filters, drive correctors, cameras and the like. Although it may not be considered an accessory in the conventional sense, a well-stocked astronomical library is just as valuable to getting more satisfaction out of your hobby. A good book collection helps you plan observing sessions, increases your knowledge of astronomy, or simply entertains.

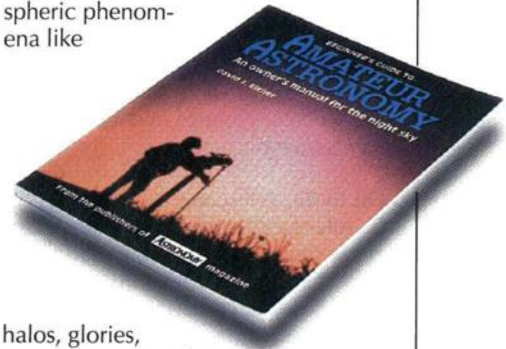
Since there's no shortage of astronomy books to choose from, compiling a basic library might seem a daunting task. To get you started, consider some favorites I've added to my bookshelf over the years. Each title in the listing has an ISBN number and the publisher's name so you can order the book from any bookseller. Some titles relay advice to beginners while others delve into the nuances of astrophotography. All communicate the depth and richness of astronomy and deserve a prominent spot on any amateur astronomer's bookshelf.

Laying a Cornerstone

Books that review astronomy form an essential cornerstone of a good astro-library. They provide information and advice on equipment and observing techniques. If you are just entering the hobby, the *Beginner's Guide To Amateur Astronomy: An Owner's Manual for the Night Sky* (Kalmbach, 1993, 166 pages $19.95, ISBN 0-913135-18-6) by Dave Eicher is the perfect first book. It starts with an essay on where amateur astronomy is today before moving onto naked eye stargazing. Eicher then introduces observing, beginning with the planets, and working toward deep sky. He concludes with another essay on the future of amateur astronomy. Unlike other works that give too much detail, *Beginner's Guide* remains simple. No atlases or catalogs here, just descriptions of what you can see.


THE BACKYARD ASTRONOMER'S GUIDE
TERENCE DICKINSON & ALAN DYER

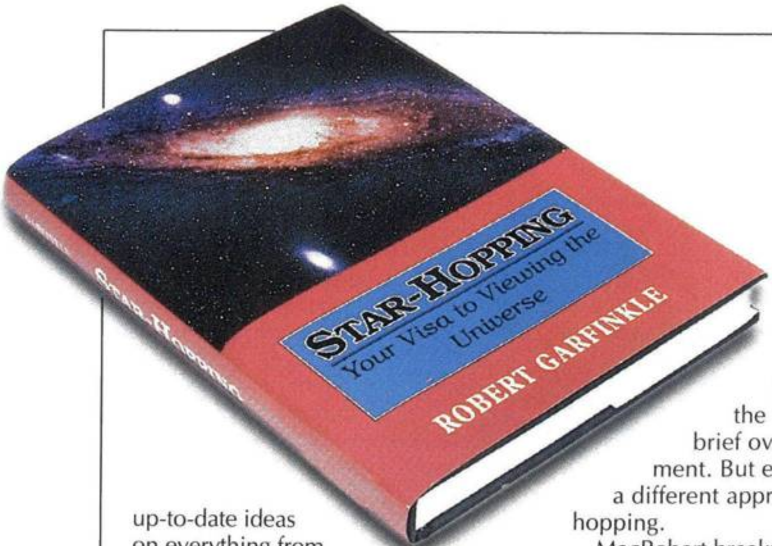
The Backyard Astronomer's Guide (Camden House, 1991, 295 pages, $39.95, ISBN 0-921820-11-9) by Terence Dickinson and Alan Dyer goes into more detail. It begins with a general discussion of telescopes, eyepieces, and other equipment that an amateur uses. Equipment comes up again in chapters that deal with observing and photography. For example, the section on projection photography mentions how to use the right combination of extension tubes and eyepieces. *Backyard Astronomer* also covers atmospheric phenomena like halos, glories, coronas, crepuscular rays, and the green flash. Appendices deal with collimation and optical evaluation. There is also a small star atlas.


BEGINNER'S GUIDE TO AMATEUR ASTRONOMY
An owner's manual for the night sky
David J. Eicher
From the publishers of Astronomy magazine

Sometimes all you need to enjoy the sky is a star atlas and binoculars. *Binocular Astronomy* (Willmann-Bell, Inc., 1992, 182 pages, $24.95, ISBN 0-943396-36-0) by Craig Crossen and Wil Tirion tells you how to select binoculars useful in astronomy and use them to look at the Moon, planets, and deep-sky. *Binocular Astronomy* is broken down by constellation within each season. The book is liberally illustrated with black and white photos, and it has plenty of star charts to help you find objects.

After tapping this bonanza of observing and equipment advice, it helps to understand what you're looking at. Often the best book for this job is a general astronomy textbook. One that stands out is *Exploration of the Universe* (Saunders College Publishing Company, 1995, 690 pages, ISBN 0-03-001034-9) by David Morrison, Sidney Wolff, and Andrew Fraknoi. The book starts in our solar system and then moves out into our galaxy and beyond. Since *Exploration* is geared towards college students, its information is clear, concise, and to the point. Chapters are organized for ready access to information, have a minimal amount of math. This seventh edition includes

ASTRONOMY: Chris Becker

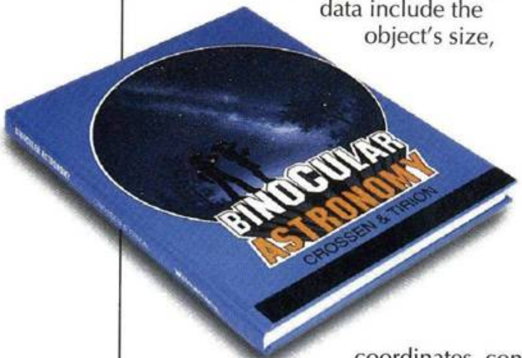


up-to-date ideas on everything from the Sun to cosmology. Lots of color pictures liven things up too.

On to the Telescope

After gauging the nature of and answering questions about astronomy, it's time to sample the variety of observing you can do with a telescope. Books that offer specific tips and techniques for observing specific objects are handy here.

David Eicher's *Beyond the Solar System* (Kalmbach Publishing, 1992, 80 pages, $12.95, ISBN 0-913135-10-0) presents 100 of the best deep-sky observing targets. It begins with a one-page explanation about the types of objects you can see. After that, it presents 100 deep-sky objects, each with a photograph and some pertinent information. The data include the object's size, coordinates, constellation , magnitude, and Messier or NGC designation. There are also directions on how to hop from nearby stars to deep-sky objects.



Finding objects through star hopping is the focus of *Star Hopping for Backyard Astronomers* (Sky Publishing Corp., 1993, 160 pages, $24.95, ISBN 0-933346-68-9) by Alan MacRobert and *Star Hopping: Your Visa to Viewing the Universe* (Cambridge University Press, 1994, 329 pages, $24.95, ISBN 0-521-41590-X) by Robert Garfinkle. Both books start with a short introduction to the night sky and a brief overview of equipment. But each book takes a different approach to star-hopping.

MacRobert breaks objects down by constellation and illustrates star hopping with star charts and photographs. Charts have white stars on a dark background, with 5° or 1° field circles that guide you to the objects. Garfinkle's book, on the other hand, presents objects by season. After that, its descriptions of deep-sky objects and how to find them using charts are similar to MacRobert's.

Visual Astronomy of the Deep Sky (Cambridge University Press, 1990, 355 pages, $39.95, ISBN 0-521-36155-9) by Roger Clark shows how deep-sky objects look through a telescope. Clark includes both drawings and photographs so you can compare the two side-by-side at the eyepiece. He even provides drawings of star clusters and lists the magnitude of various star members to help you estimate how faint you're seeing.

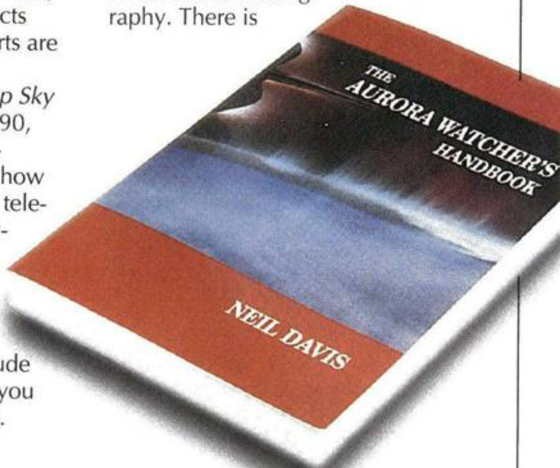
More than Deep-sky

So far we've explored observing books devoted primarily to deep-sky, but there is far more to see than galaxies, star clusters, and nebulae.

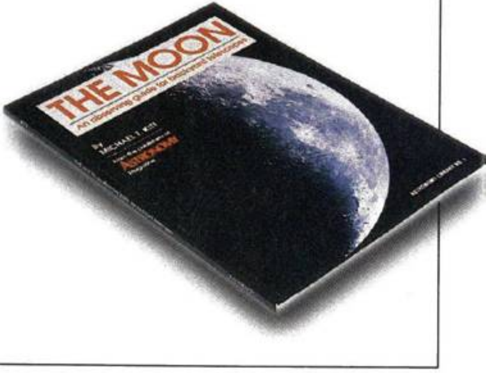
An Introduction to Observing and Photographing the Solar System (Willmann-Bell, 1988, 215 pages, $24.95, ISBN 0-02-948980-6) by Thomas Dobbins, Donald C. Parker, and Charles Capen is the only book you'll need to enjoy the solar system with a telescope. Except for the Sun, the authors devote a chapter to each type of solar system object, detailing when and how to observe or photograph them. The book details what equipment and techniques work best, and tells how you can get involved in an active effort to monitor the activity of some planets.

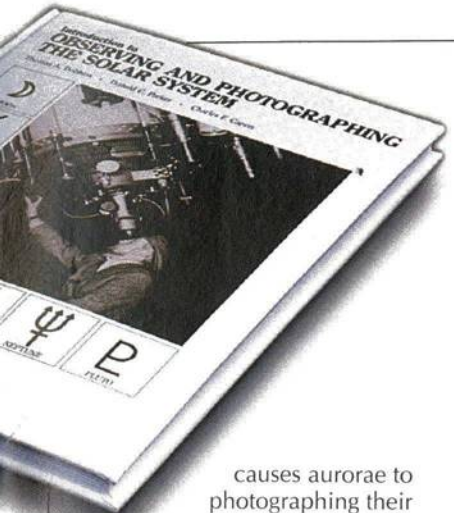
After getting the big solar system picture, move onto *The Moon: An Observing Guide for Backyard Telescopes* (Kalmbach Publishing, 1992, 80 pages, $11.95, ISBN 0-913135-09-7), written by expert lunar observer Michael Kitt. This book lists the 100 most prominent features on the Moon with descriptions for all of them and photographs or drawings for most. It also explains what geological events produced these features.

Far more fleeting and just as interesting are so-called "shooting stars." *Observe Meteors* by David Levy and Stephen Edberg is the official guide to observing and photographing meteors from the Association of Lunar and Planetary Observers, an amateur astronomy group. The book contains an extensive list of meteor showers visible throughout the year, report forms, and an extensive bibliography. There is even a section on recording meteors using radio telescopes.



Another transient, awe-inspiring sight in the night sky are the elusive Northern Lights. *The Aurora Watcher's Handbook* (University of Alaska Press, 1992, 230 pages, ISBN 0-912006-60-9) by Neil Davis is one of the few aurora books on the market. It covers everything from what

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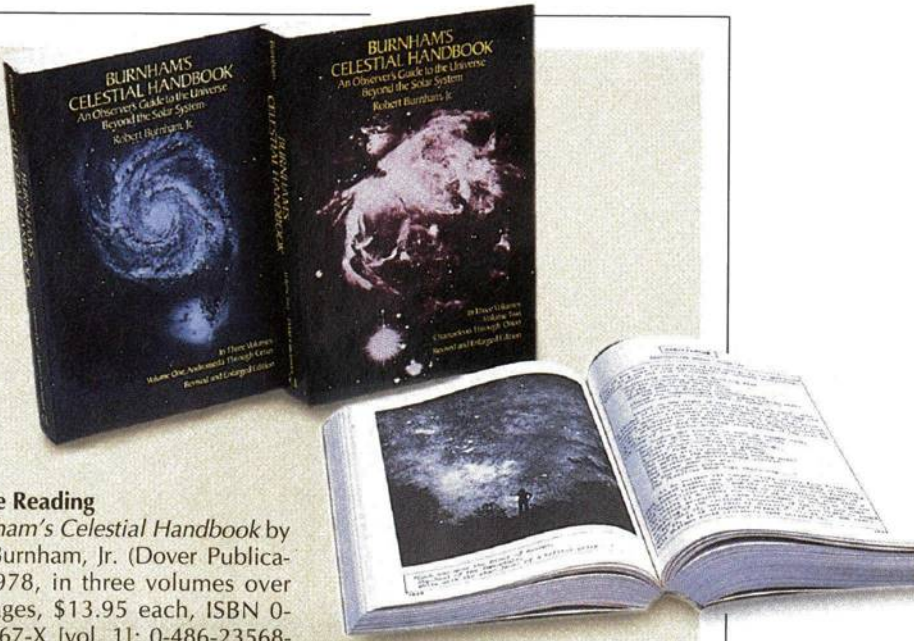
BURNHAM'S
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An Observer's Guide to the Universe
Beyond the Solar System
Robert Burnham, Jr.
BURNHAM'S
CELESTIAL HANDBOOK
An Observer's Guide to the Universe
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Robert Burnham, Jr.

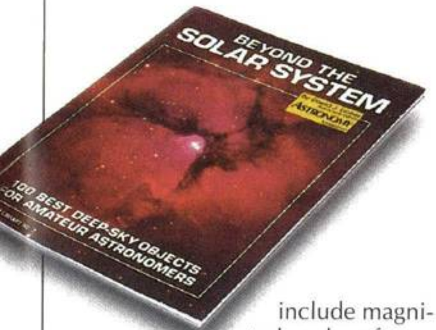
Requisite Reading

Burnham's Celestial Handbook by Robert Burnham, Jr. (Dover Publications, 1978, in three volumes over 2138 pages, $13.95 each, ISBN 0-486-23567-X [vol. 1]; 0-486-23568-8 [vol. 2]; 0-486-23673-0 [vol. 3].)

This three-volume set profiles interesting deep-sky objects, shares scientific findings, and delves into sky lore alphabetically by constellation. Each constellation entry opens with a list of double, variable, and multiple stars, followed by a table of deep-sky objects. Lengthy discussions that use pictures and drawings of notable objects in the constellation fill out each section. For many night-sky enthusiasts, this work is the first and last word on the night sky, and is the perfect companion to any star atlas.

causes aurorae to photographing their marvelous spectacle. The author uses black and white and color photographs to show the different types of aurorae. Liberal use of diagrams help illustrate some of the concepts covered in the text.

One popular way of contributing to science is by observing and logging stars that vary in brightness. *Observing Variable Stars: A Guide for the Beginner* (Cambridge University Press, 1989, 198 pages, $24.95, ISBN 0-521-32113-1) by David Levy is devoted completely to this field, beginning with how to find variables and then how to estimate their brightness. Levy gives a tour of variable types and explains what each type tells us about the nature of stars in general. Finder maps include magnitude values for nearby, non-varying stars so you can make magnitude estimates.


BEYOND THE
SOLAR SYSTEM
ASTRONOMY
100 BEST DEEP-SKY OBJECTS
FOR AMATEUR ASTRONOMERS

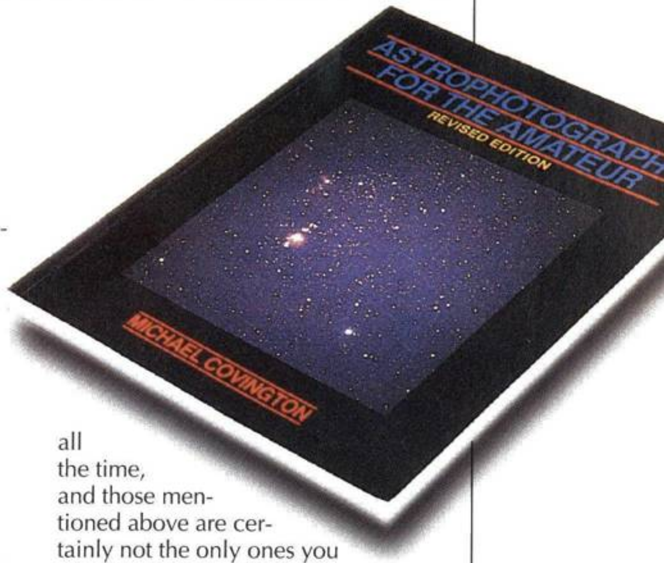
Starlight Forever

Observing the night sky has its pleasures, but preserving the view as a photograph compels amateurs to take cameras out under the night sky. Several good books will help you get the most out of your astrophotographic pursuits.

The *Cambridge Deep Sky Album* (AstroMedia, 1983, 126 pages, ISBN 0-943396-17-4) by Jack Newton and Philip Teece is full of pretty color photos of many deep-sky targets. Album is one of the few deep-sky photo books on the market entirely composed of pictures taken by amateur astronomers. Author Jack Newton shot most of the photos using a homemade astro camera that can be built from scratch by following the instructions in the book.

For beginning and intermediate astrophotographers, there is *Astrophotography for the Amateur* (Cambridge University Press, 1992, 168 pages, $24.95, ISBN 0-521-40984-5) by Michael Covington. The book uses a bevy of graphs, line drawings, and photos to lay out many of the options available to an astrophotographer, from easy constellation shots to eyepiece-projection photography of the Moon. Demonstration pictures appear in both black and white and color.

The Manual of Advanced Celestial Photography (Cambridge University Press, 1988, 388 pages, $47.95, ISBN 0-521-25553-8) by Brad Wallis and Robert Provin is a milestone for the advanced astro-imager. This is the most detailed coverage of celestial photography I have ever seen in an astronomy book! The authors cover everything from guiding a telescope during an exposure to tricks of the trade you can try in the darkroom. The book also includes tips by some of the best astrophotographers in the field.


ASTROPHOTOGRAPHY
FOR THE AMATEUR
REVISED EDITION
MICHAEL COVINGTON

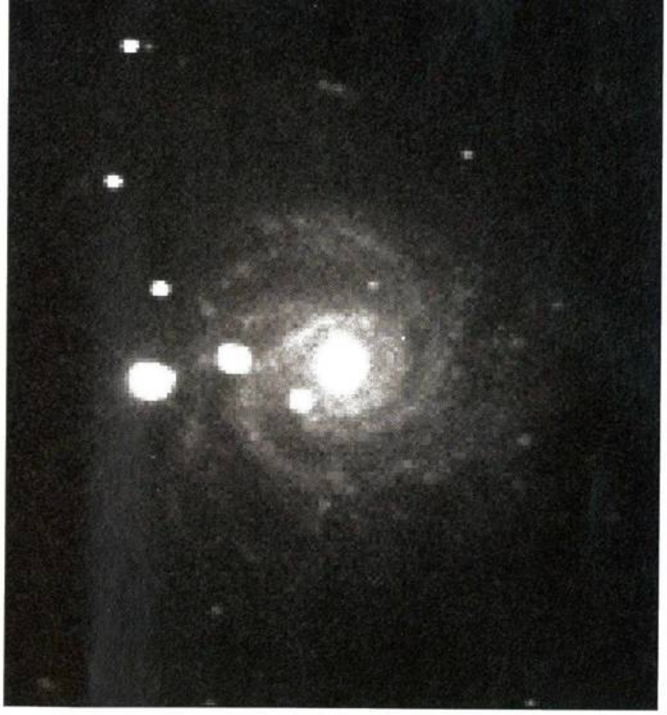
Astronomy books are appearing all the time, and those mentioned above are certainly not the only ones you should consider. Go to your public library and "test drive" different titles. Attend an astronomy club meeting to tabulate the favorites of other amateurs. Read the AstroBooks column of ASTRONOMY to catch new titles. Finally, scan the magazine for ads by book publishers and sellers. Your astro-library is a lifelong project, one that will expand and grow along with your interests in the hobby. ☐

Mark Coco enjoys writing about and doing amateur astronomy in Southern California.

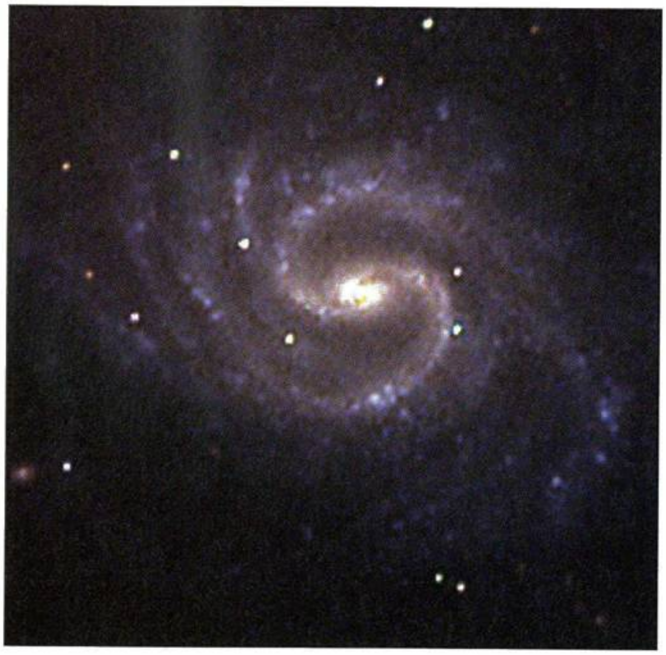
When Galaxies Strut Their Stuff

Knotty arms, pinpoint nuclei, bright bars, and regions where stars are forming — face-on spirals offer the most detail for observers with medium-size telescopes.

by David J. Eicher



NGC 3344 in Leo Minor
by Jerry Armstrong and Tim Puckett
(16-inch f/6 reflector, ST-6 CCD camera)

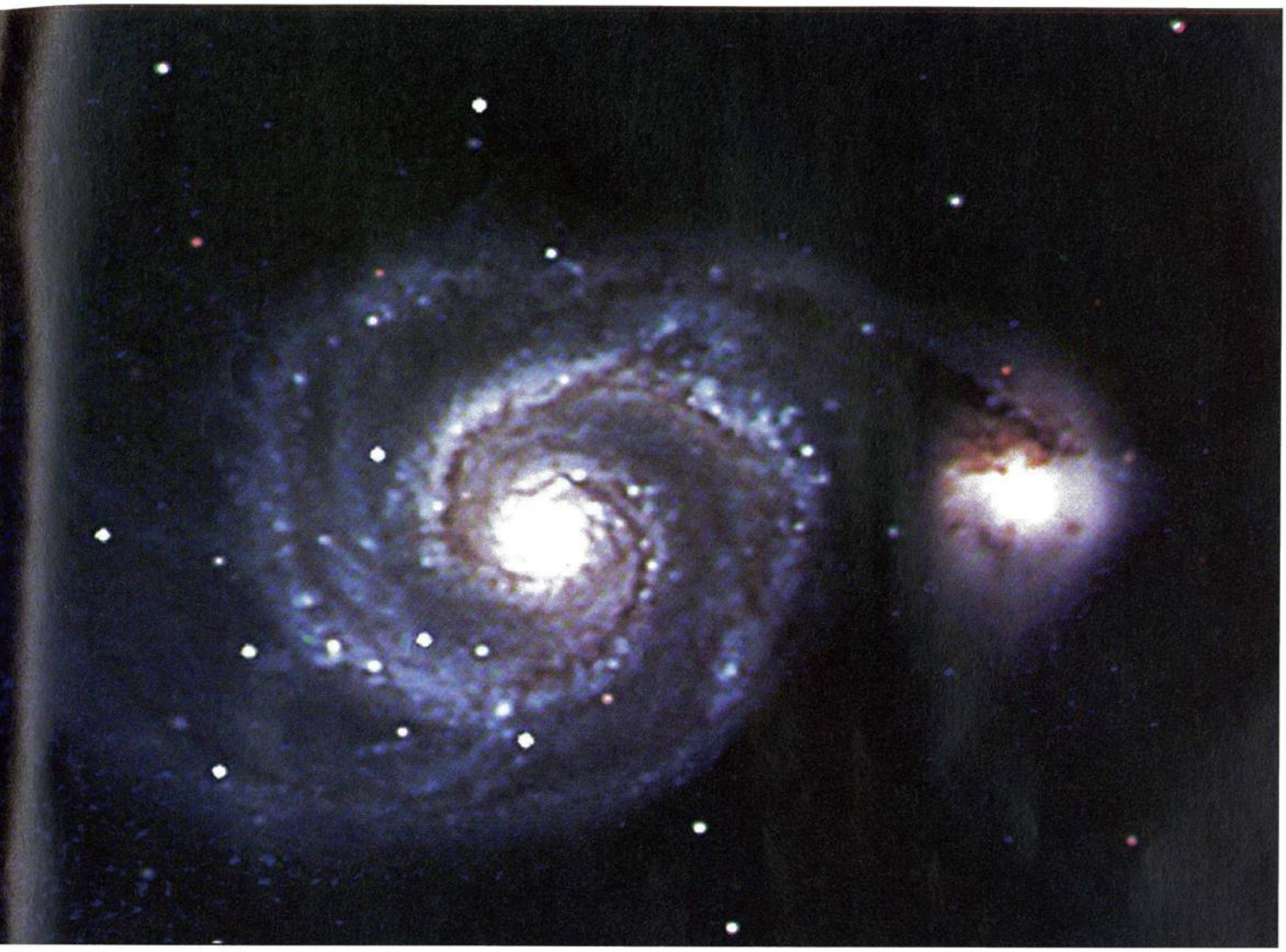


NGC 4535 in Virgo
by Jack Newton
(25-inch f/5 reflector, ST-6 CCD camera)

M95 in Leo
by Greg Terrance
(16-inch f/5 reflector, ST-6 CCD camera)

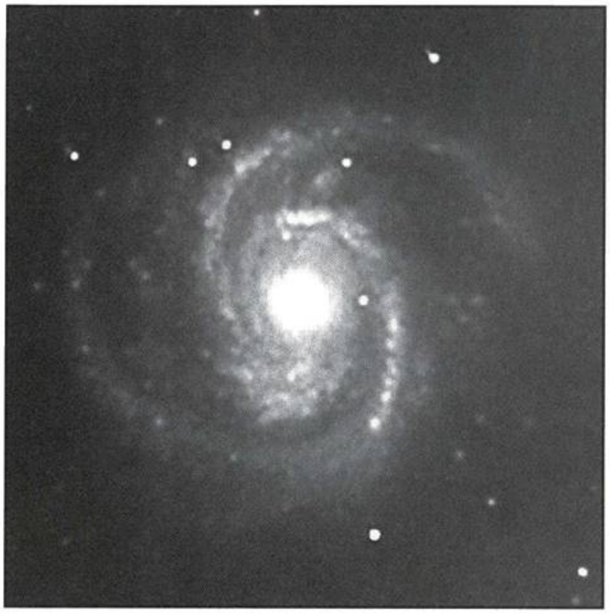
The best way to read a person is with a good, long look in the face. The same holds for a galaxy, too. The challenge for backyard observers is that galaxies come in all shapes, sizes, and orientations. But there's a class of galaxies that will provide hours of detail for observers with a 6-inch or larger scope: face-on spirals.

By their very nature, spiral galaxies have lots of features. These include bright centers, a circular or elliptical set of spiral arms, and a faint outer haze enveloping the galaxy. Sometimes the feature is a bright bar or blazing, pinpoint nucleus, or a clumpy little feature called an HII region, where stars are forming, scattered throughout the arms. When a spiral galaxy is both relatively nearby and oriented more or less with its face toward us, the conditions are best for



The Whirlpool Galaxy
by Jack Newton
(25-inch f/5 reflector, Pictor 1616 CCD camera)

M100 in Coma Berenices
by Jack Newton
(25-inch f/5 reflector, Pictor 1616 CCD camera)



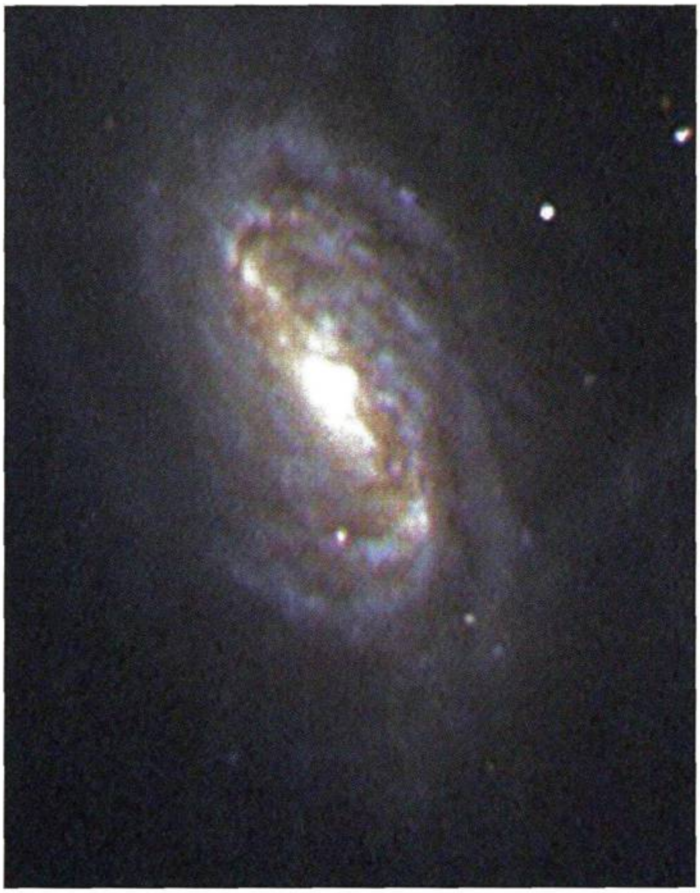
picking out some of these details in the kinds of telescopes we haul out into our backyards or to dark-sky observing sites.

As an example, take an old favorite that's easy to find, **M101** in Ursa Major, not far from the handle of the Big Dipper. This relative neighbor lies just 15 million light-years away. The hallmarks of M101 are loose, well-defined arms with little knots of detail. It's a simple hop from Mizar up through the line of 81, 83, 84, and 86 Ursae Majoris to this big, hazy, low surface-brightness spiral. On a moonless night, a 6-inch scope shows a hazy circular glow surrounding a bright center, and a hint of a spiral arm pattern if the transparency is good. An 8-inch or 10-inch scope brings out the spiral pattern. But rather than a continuous swath of light, its spiral arms are made up of little patches that do not connect. Traces of dust between the arms are visible in larger scopes, as are the HII regions that mark the sites of recent starbirth. Similar but more challenging examples may be found in Triangulum's **M33**, **NGC 2403** in Camelopardalis, and **NGC 6946** in Cepheus.

M101 is a good object for very dark nights because it reveals the effects of what's going on inside a galaxy. Another example of this exists in the more distant galaxy **M100** in Coma Berenices, a member of the Virgo Cluster of galaxies. M100 lies just shy of 2° northeast of 6 Comae Berenices, and is surrounded by a minicloud of dimmer galaxies. It's become famous as the Hubble "poster child," in that it was the object used by astronomers working with the Hubble Space Telescope to accurately measure the distance to the Virgo Cluster. This distance appears to be about 55 million light-years.

Even at this distance, the galaxy reveals some details on dark, transparent nights. A good 10-inch scope reveals a bright center surrounded by a faint spiral pattern peppered with a few dim stars. The spiral shape of this galaxy is highly symmetrical, and under optimum conditions it stands out against the sky background. The galaxy's graceful arms permit seeing the organization that permeates its inner structure. Other such lovely face-on galaxies with well-defined arms include **M61** in Virgo, **M74** in Pisces, **M83** in Hydra, and **NGC 3344** in the faint constellation Leo Minor.

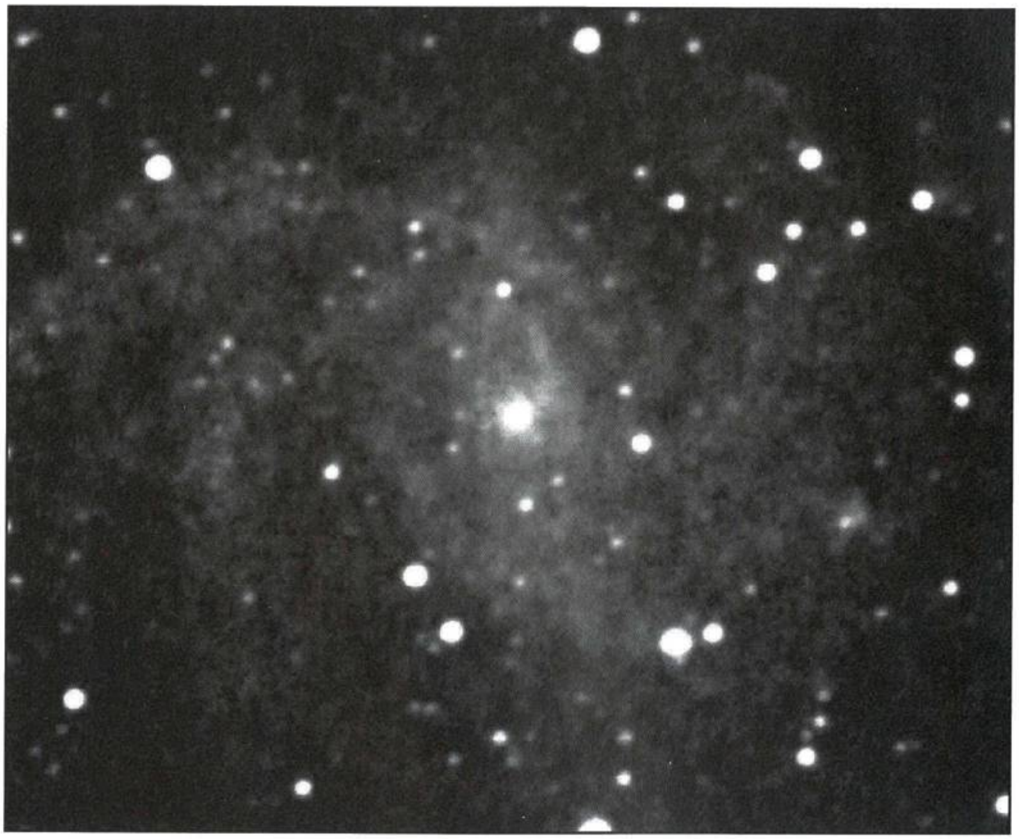
Many other galaxies at a broad range of distances, some almost



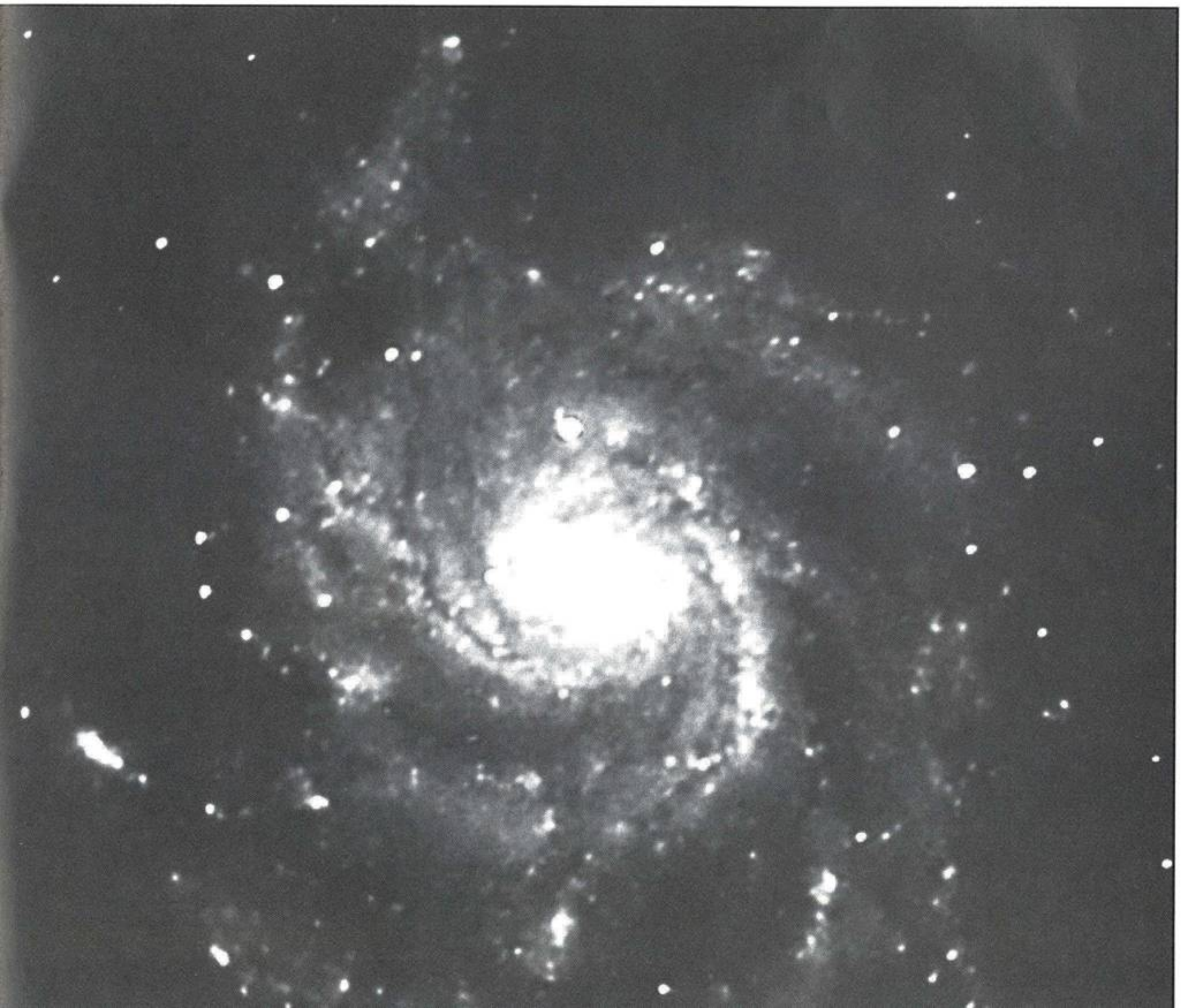
NGC 2903 in Leo
by Jack Newton
(25-inch f/5 reflector, ST-6 CCD camera)

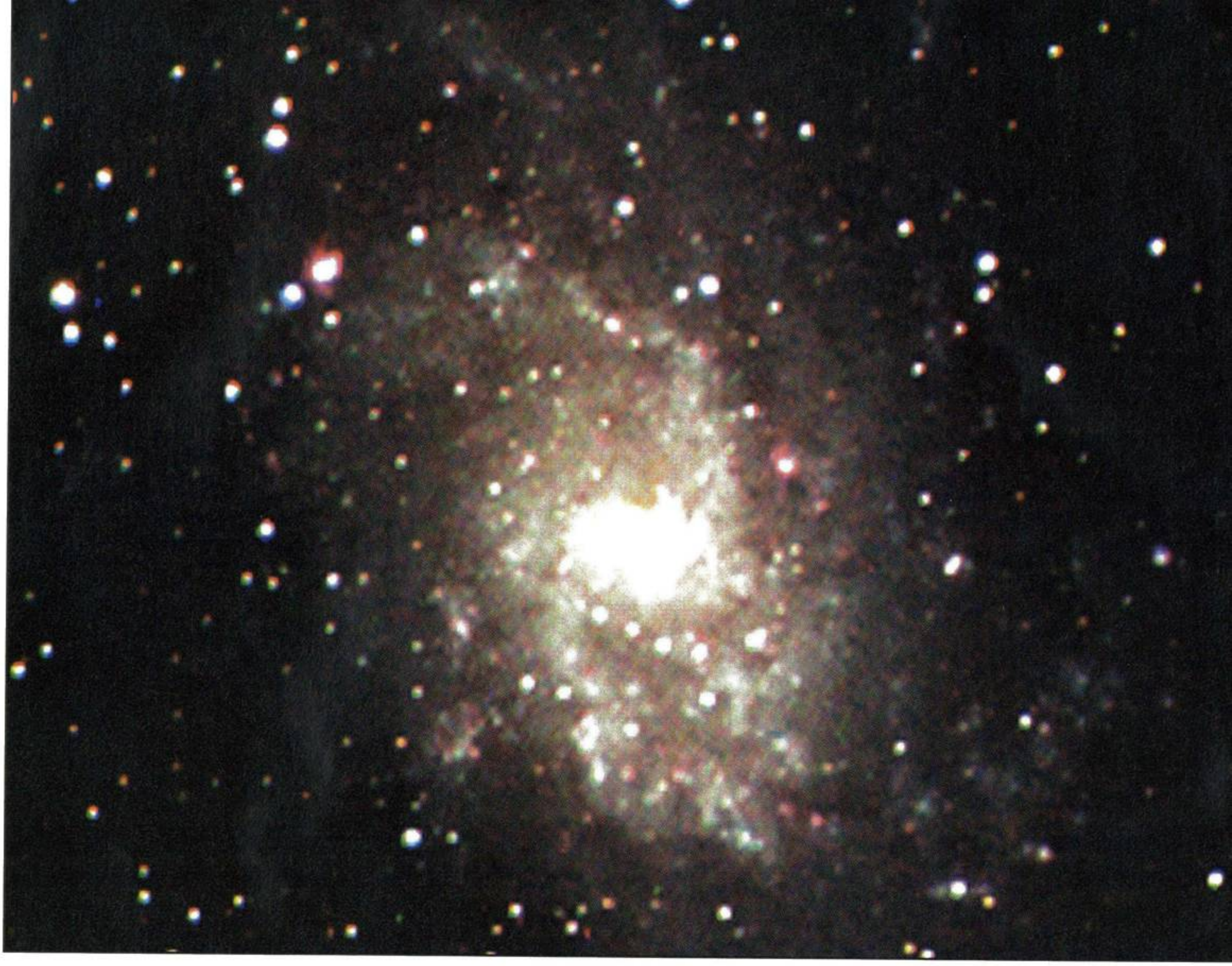
NGC 2403 in Camelopardalis
by Jack Newton
(25-inch f/5 reflector,
ST-6 CCD camera)

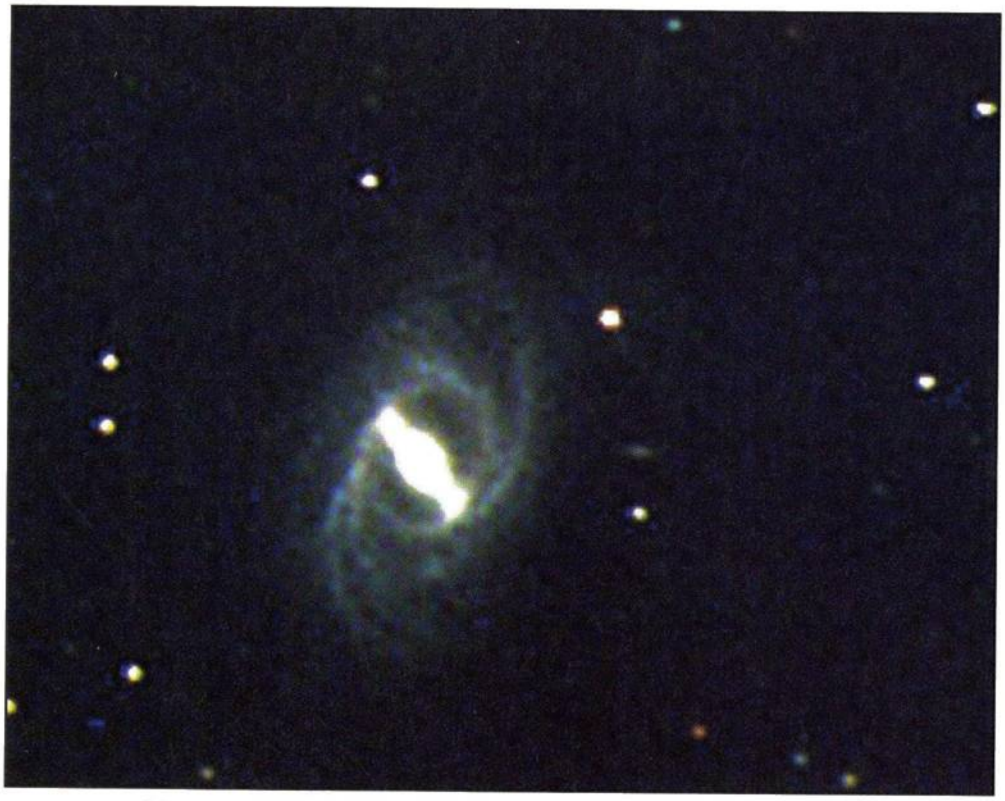
NGC 6946
in Cepheus
by Stéphane Dumont
(9-inch SCT at f/12,
ST-6 CCD camera)



M101 in Ursa Major
by Jack Newton
(25-inch f/5 reflector, Pictor
1616 CCD camera)

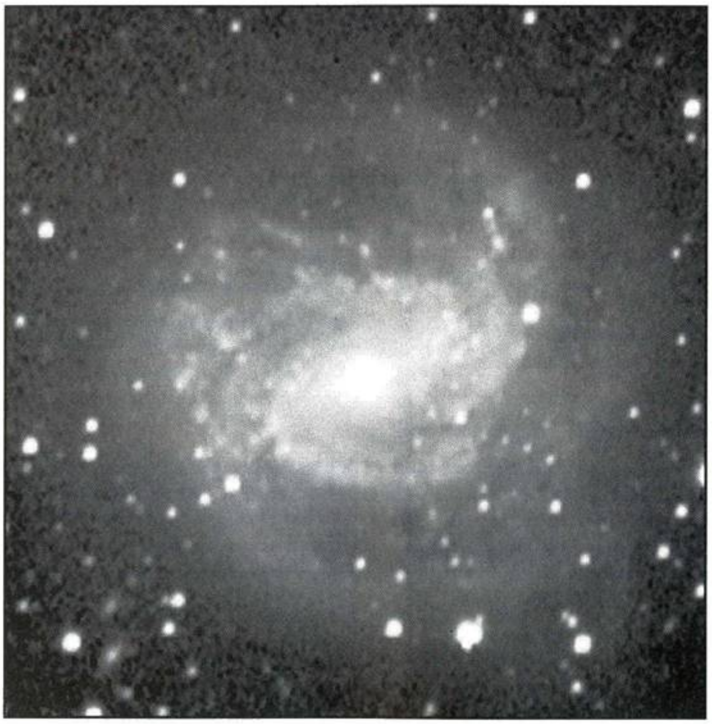






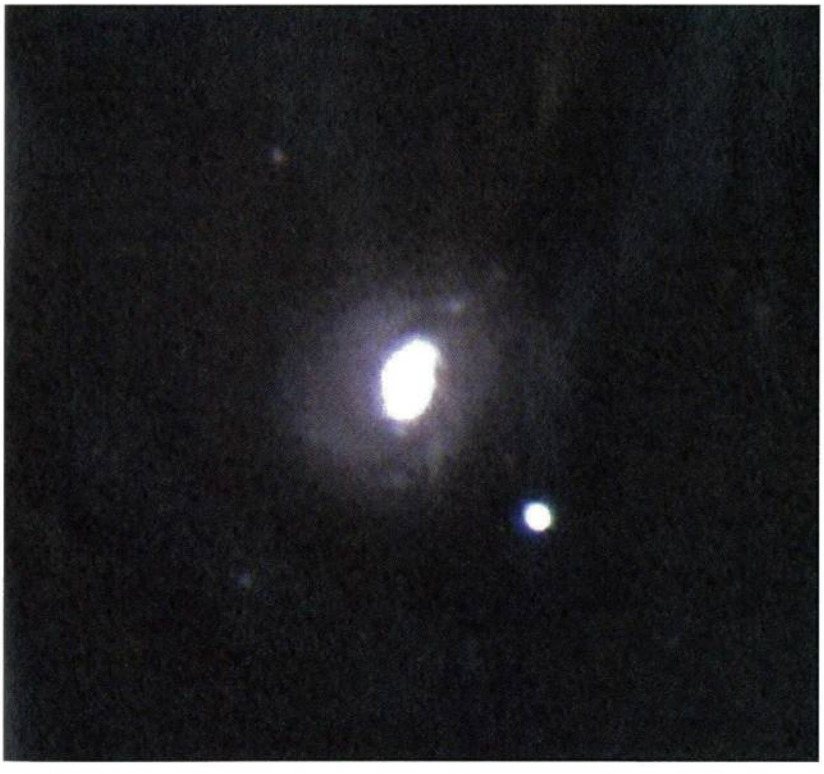
M33 in Triangulum
by Nik Syzmanek and Ian King
(4-inch refractor at f/7,
ST-6 CCD camera)

NGC 2523 in Camelopardalis
by Jack Newton
(25-inch f/5 reflector,
ST-6 CCD camera)



M83 in Hydra
by Steven Lee
(8-inch reflector, Cookbook 245 CCD camera)

M77 in Cetus
by Jack Newton
(25-inch f/5 reflector, ST-6 CCD camera)



exactly face-on, others not quite so, offer a wealth of splendid views. The **Whirlpool Galaxy** (M51) in Canes Venatici, another galaxy near the Big Dipper, reveals one of the brightest examples of galaxy interaction. The large, face-on spiral pattern visible in small scopes in the main galaxy is accompanied by a cosmic interloper, **NGC 5195**, a smaller galaxy that is passing by the spiral and drawing a bridge of material away from it. This celestial drama requires only a 6-inch telescope to be seen.

Just a dipper-length away, tucked beneath the bowl of the Big Dipper, is the barred spiral galaxy **M109**. Barred spirals have a luminous bar extending through the galaxy's center and connecting to the originating point of its arms. This remarkable structure in M109, still not understood by those who study the dynamics of galaxies, is plainly visible in an 8-inch scope on a dark night. The galaxy's very bright hub, the extended core of light that surrounds its tiny nucleus, lies entwined in a faint halo of misty light arranged in a graceful spiral pattern. This scene presents itself across a gulf of 45 million light-years of cold, black space. Other prominent barred spirals include **M95** in Leo, **NGC 2523** in Camelopardalis, and **NGC 4535** in the bright constellation Virgo.

A huge number of galaxies not oriented exactly face-on and at slightly greater distances hang in the sky to test your observing mettle. For example, the Seyfert galaxy **M77** in Cetus offers an unusual challenge. The term Seyfert refers to Carl Seyfert, an American astronomer who identified a peculiar class of galaxies with highly energetic centers. The faint spiral pattern of M77's arms stands out in large backyard telescopes, but the humblest of instruments show the galaxy's brilliantly glowing, compact center. An ancient black hole in the center of the galaxy, having mostly run out of material to swallow, may cause the sputtering belches of energy that flow from this strange object. Other galaxies with bright centers include **M58** in Virgo and **NGC 2903** in Leo.

Each of these distant islands of stars, gas, and dust offers a different view in the eyepiece. As the winter nights grow dark and the skies clear overhead, haul out your telescope and explore a few of these distant cousins of the Milky Way. The features you may see will sharpen your vision for other deep-sky objects down the line in your observing career. □

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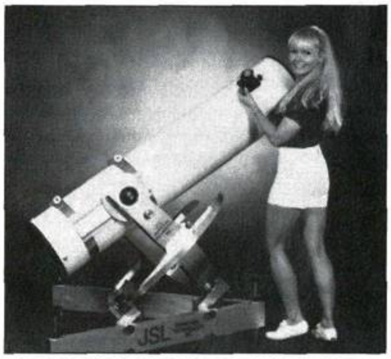

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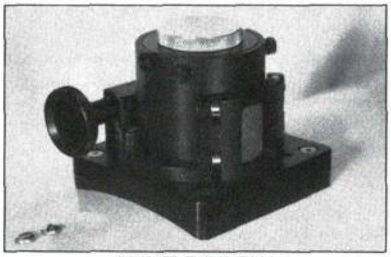

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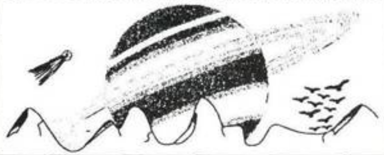

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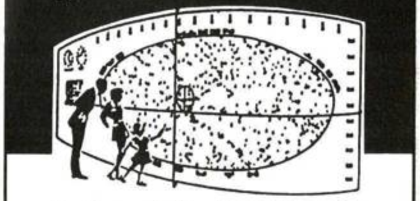

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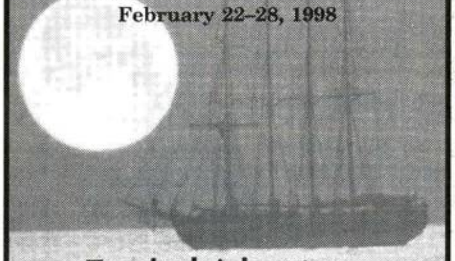

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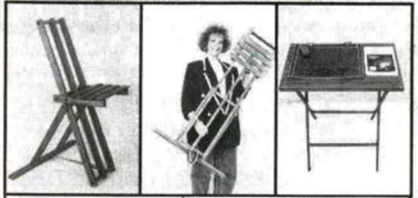

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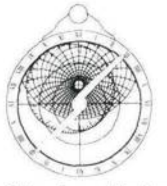

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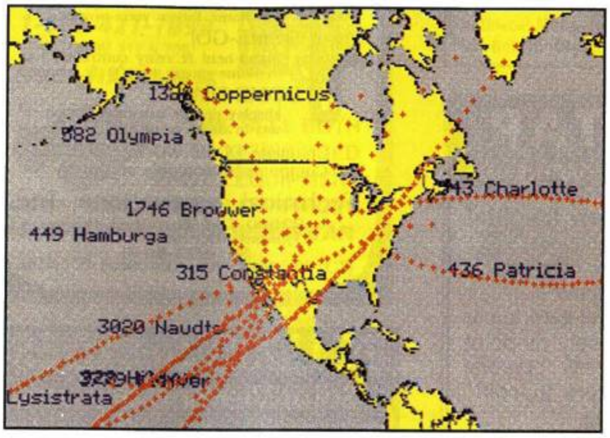

Asteroid Pro 2.0

Pickering Anomalies, P.O. Box 1214, Belmont, CA 94002, (415) 593-7332, fax (415) 592-1702. Price for Level I: $169.95; upgrade from version 1.x: $40. Price for Level II: $199.95; upgrade to Level II from Level I: $50; upgrade from version 1.x: $70. Minimum requirements: 80386-based computer, 500 KB of free memory, 60 MB of free disk space, DOS 5.0 (will run in Windows 3.1), a mouse, and a color SVGA display. Level II also requires a CD-ROM drive.

Predicting when an asteroid will pass in front of a star and occult, or block, its light requires extremely accurate star positions and orbital calculations. *Asteroid Pro* provides these in a comprehensive package that also displays the path of the asteroid's shadow on Earth, plots its orbital path in the sky, and searches for future occultations. Users can enter the latitude and longitude of an observing site and select searches on the basis of date, brightness, visual criteria, and shadow duration.

To achieve its accuracy, the program uses the latest asteroid orbital elements (six quantities that specify an orbit, listed for epoch November 5, 1996) from the Institute of Theoretical Astronomy in St. Petersburg, Russia, and perturbed orbits to refine asteroid positions at other dates. The orbital calculations should permit predictions of stellar occultations within several years of the epoch to pinpoint events of interest to an observer. As with any accurate occultation prediction, small errors in an asteroid's orbital elements can affect the ground path of the asteroid's shadow by several hundred miles. Planning for a particular event requires a redetermination of the asteroid's position shortly before the event to update orbit and ground path calculations. The International Occultation Timing Association (2760 SW Jewell Ave., Topeka, KS 66611-1614) provides detailed updates.

Asteroid Pro has two versions. Level I tracks 6,160 asteroids and uses a stellar database of more than 550,000 stars from the *Positions and Proper Motions Star Catalogue, Astrographic Catalog of Reference Stars,* and other catalogs. (Version 1.7 only had 5,500 asteroids and 340,000 stars in its database.) The program includes the proper motions of stars (the motions across the sky due to the stars' movement through space) in its predictions of events. Users can import the results of the calculations to *TheSky, Dance of the Planets, Epoch 2000,* and other planetarium programs to produce finder charts.

Level II of *Asteroid Pro* comes on a CD-ROM. It has the same number of asteroids as Level I but adds 6,600,000 stars from the *Hubble Guide Star Catalog,* extending the database down to magnitude 13.5. A special procedure handles multiple entries in the *Hubble Guide Star Catalog.* The CD-ROM format minimizes occultation search times.

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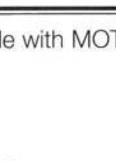

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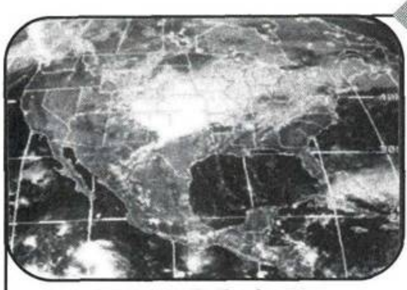

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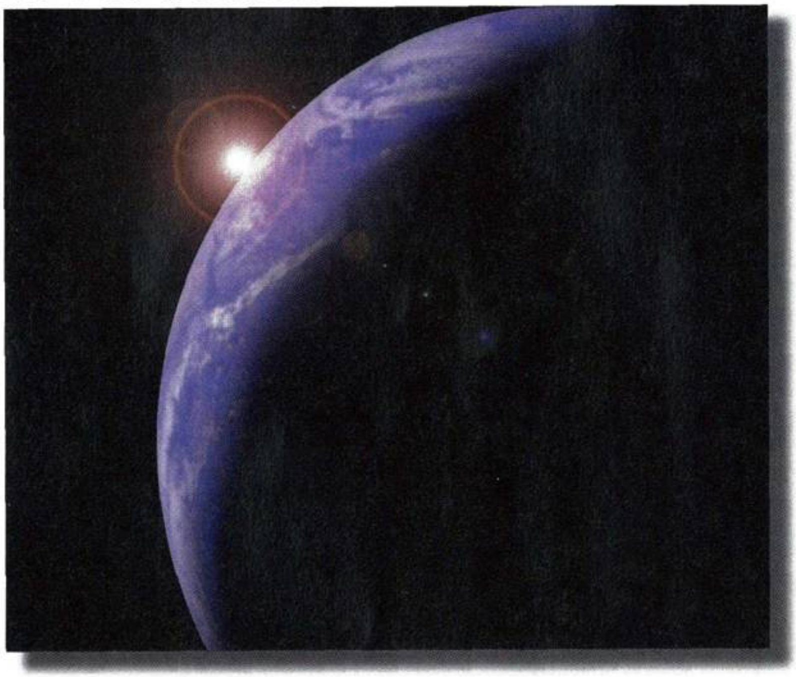

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Voyager, long a mainstay planetarium program of astronomy enthusiasts who use Macintoshes, now has a new version. The standard edition plots the Moon and planets, hundreds of asteroids and comets, 259,000 stars down to magnitude 9.5, 4,000 variable stars, 2,000 double stars, and 12,000 deep-sky objects from the *New General Catalogue, Uppsala General Catalogue,* and *Index Catalogues.*

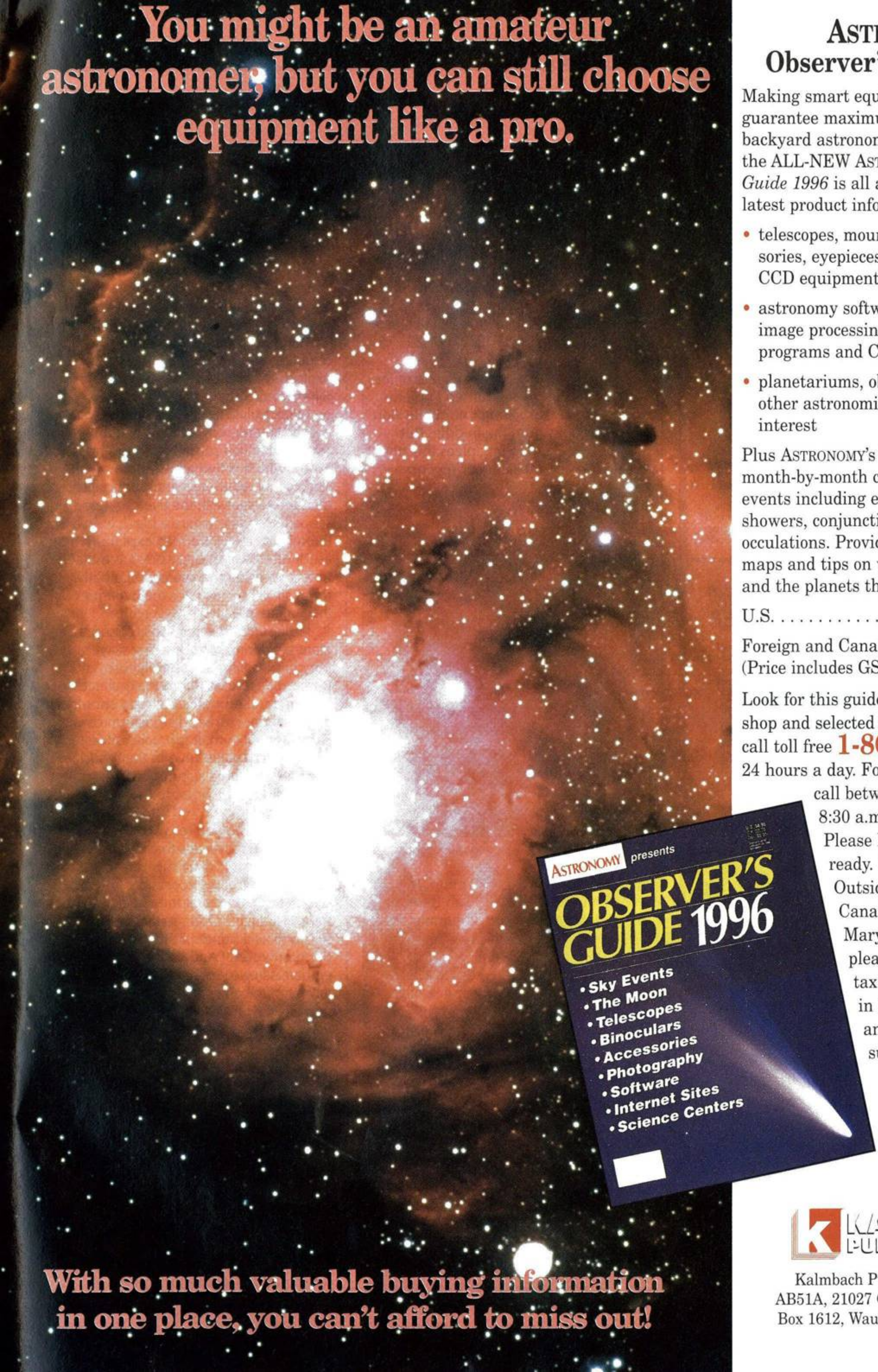
The CD-ROM version offers extended catalogs including an additional 10,000 deep-sky objects, 5,400 asteroids, 1,400 comets, 20,000 double stars, the *General Catalogue of Variable Stars* with 28,400 stars, the *Hubble Guide Star Catalog* with 15 million stars down to 16th magnitude, and a gallery of 800 images taken by notable astro-imagers such as David Malin and Tony and Daphne Hallas. The disk includes a subset of the *Guide Star Catalog* for field use on portable computers. It has 4 million stars down to magnitude 12.5.

In addition to the new CD-ROM catalog extensions, the latest version of *Voyager* offers a few new features. Sky View is a new window that magnifies the view of a selected area. Scope owners can use the Sky Chart and Sky View windows to show a finderscope and eyepiece view of a region. Users can display the orbits of binary stars to see how the stars change position over time. They can also capture the motions of the sky and the paths of planets as QuickTime movies.

Satellite followers can now track satellites as they zoom around Earth. Armchair astronomers will enjoy plotting 3D maps of nearby stars, star clusters, nebulae, and the Local Group of galaxies.

The optional *SkyPilot* program ($50) remotely controls a scope through *Voyager.* Users can see where their scopes are pointing by noting the crosshair on the computer screen. Or they can click on an object on the Sky Chart and have the scope slew to that position. *SkyPilot* works with Meade LX200, LX700-750, and other scopes fitted with encoders or digital readouts. ☐

Software developers may send new programs and upgrades to AstroBytes, ASTRONOMY Magazine, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out ASTRONOMY's home page at **http://www.kalmbach.com/astro/astronomy.html.**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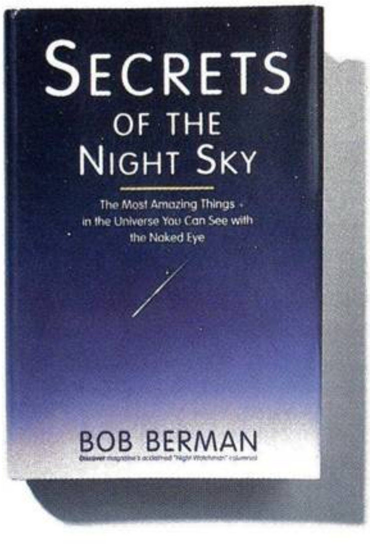
ASTRO BOOKS

Hallways of the Night

Secrets of the Night Sky: The Most Amazing Things in the Universe You Can See with the Naked Eye
Bob Berman (William Morrow and Company, Inc., 1995), ISBN 0-688-12727-4, 320 pages, hardcover, $23.00.

When I first picked up *Secrets of the Night Sky* in August, I turned immediately to page 167. I don't normally start reading books from the middle. But author Bob Berman organizes this one by season and the summer section happens to fall near the center. If you're not familiar with Bob Berman, the "Night Watchman" columnist for *Discover* magazine, then you're in for a treat. Berman has a conversational, humorous tone that invites readers into the cosmos without using a lick of technical jargon.


SECRETS
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NIGHT SKY
The Most Amazing Things in the Universe You Can See with the Naked Eye
BOB BERMAN
Discover magazine's acclaimed "Night Watchman" columnist

I started my reading in the summer, but with those lazy days long gone and a nip in the air, you will probably want to start on page 19, the section about winter. Like all of the sections, "Winter" contains several chapters that each focus on a particular naked-eye scene best observed during that season. I say "scene," because not everything worth considering in any season is an object. Most are. There's the Moon, the Sun, Jupiter, satellites, meteors, eclipses, galaxies, etc. But Berman also talks about twilight, the aurora borealis, darkness, space travel, and even the favorite color of the universe.

Newcomers to the hobby might want to put off reading "Winter" until they finish the first chapter, "Coming to Terms With the Universe." Berman devotes these pages to explaining some basic astronomical words. If you find yourself slightly confused by terms such as astronomical unit, light-years, zenith, and magnitude — or if you just want a refresher — read this chapter.

Berman begins many chapters by orienting you to a particular region, then exploring a specific object that lies within. Take, for example, the chapter on black holes. In the middle of summer around midnight, you can look directly overhead at the constellation Cygnus the Swan, which is flying south through the Milky Way. Within Cygnus, although too faint to see with the eye or a telescope, is a place where a black hole is thought to reside. Berman explains why astronomers think Cygnus X-1 is a black hole and, using the analogy of a bathroom sink, he illustrates the dynamics of this collapsed star.

He approaches the topic of supergiant stars in much the same way. In the chapter "Baa Baa Betelgeuse," Berman describes the monstrous red supergiant that marks the right shoulder of Orion the Hunter. Its position over Earth's equator makes it accessible to nearly every naked eye in the world. Berman uses it as a springboard for talking about the volatile lives of supergiants.

Now maybe you're wondering, as I did, why Berman calls that chapter "Baa Baa Betelgeuse." (And this is really a comment about his accessible writing style.) It turns out that the ancient Sumerians visualized Orion's star pattern not so much as a hunter, but, well, a sheep. Berman writes, "And Betelgeuse, it's embarrassing to tell, literally means 'the armpit of the sheep.'" The whole book is peppered with similar anecdotes and little-known, quirky details you'll take pleasure in reading.

Although this book is geared for naked-eye observers, Berman includes appendices that discuss buying and using binoculars and telescopes. They are brief guidelines for those wanting to make the equipment investment.

Some observers, however, are quite content without the gadgets or gizmos. They prefer to peruse the universe unencumbered, skipping from galaxy to star to planet to satellite at their heart's content. This wonderful book lets you do that, even if you never leave your chair. — *Tracy Staedter*

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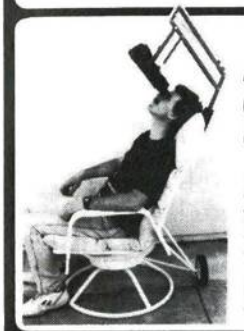

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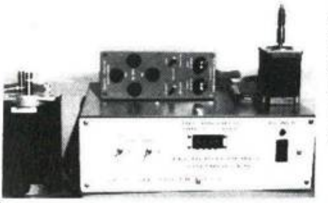

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(Review the first chapter and table of contents of Secrets of the Night Sky *on the Internet at: http://dab.psi.net/chapterone/astronomy)*

Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time

Dava Sobel, (Walker and Company, 1995), ISBN 0-8027-1312-2, 224 pages, hardcover, $19.00.

Finding one's latitude is as easy as measuring the angle to the Celestial Pole (Polaris in the Northern Hemisphere). But finding one's longitude is an altogether different matter. A navigator on the high seas must know the exact time on his ship and the exact time back in his home port; no easy task in the early days of exploration. For centuries the governments of the European maritime powers struggled to find a method for determining longitude. At stake was control of the oceans.

In 1714 the English Parliament offered a £20,000 reward ($12 million today) to anyone who could solve the problem. Noted science writer Dava Sobel tells the story of the struggle to determine longitude. The battle pitted the great astronomers of the era against a lone clockmaker, John Harrison. Sobel describes the various attempts by astronomers to sabotage Harrison's efforts. Yet in the long run, their schemes came to naught: The clockmaker prevailed. Over the course of 40 years Harrison continually improved a clock that could that could keep perfect time despite the varying conditions at sea. By the 1770s he had succeeded, thus solving the most important scientific problem of his era. Unfortunately for Harrison, he was in his late 70s when it was finally time to collect his reward, and he suffered failing eyesight and endured bouts of gout. *Longitude* is chock full of delightful stories and anecdotes, a wonderful treat for astro-history buffs.

Abell's Exploration of the Universe, Seventh Edition

David Morrison, Sidney Wolff, and Andrew Fraknoi, (Saunders College Publishing, 1995), ISBN 0-03-001034-9, 694 pages, hardcover, $57.75.

George Abell's *Exploration of the Universe* has been a standard in the college textbook market for three decades. Backyard and armchair astronomers have also long referred to *Exploration* to develop their understanding about astronomical objects and the nature of the

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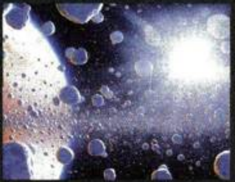
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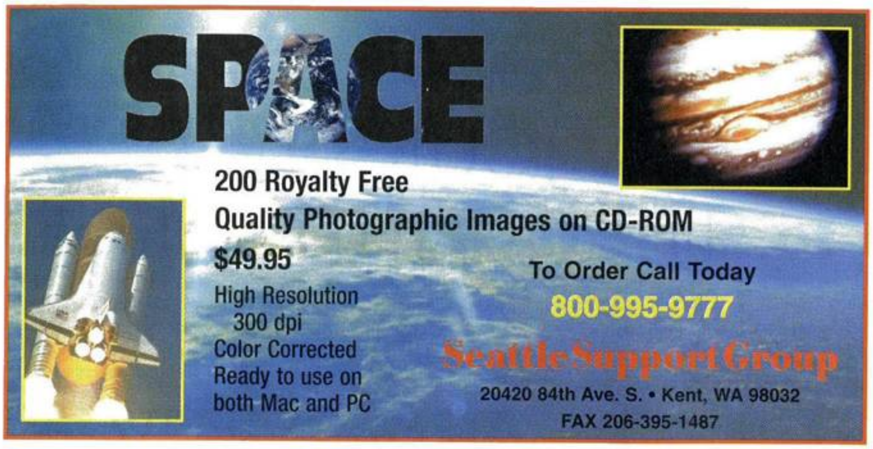
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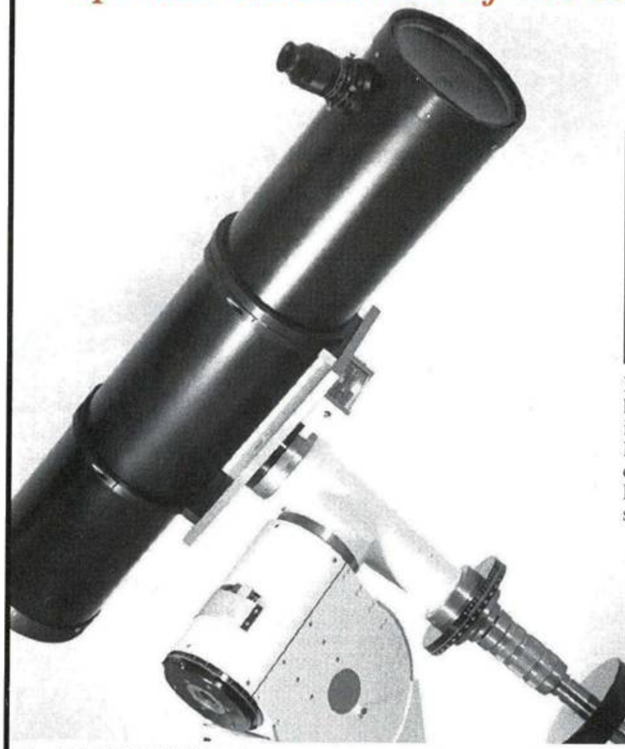

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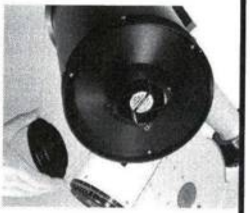

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The Universe at Your Fingertips

Edited by Andrew Fraknoi, (Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 94112, 1995), ISBN 1-886733-00-7, 813 pages, three-hole punched, $24.95.

Teachers will love this activity and resource notebook that contains more than 90 hands-on activities for use in the classroom. Although geared for grades 4-9, instructors of all levels, including college, will find the activities adaptable to their students' needs. Astronomy clubs and museums will also want this book for its rich set of resources that make astronomy and the delights of the night sky more accessible to children and beginning astronomers. In addition to the outstanding activities, the book includes reading lists, software guides, national organization lists, and articles on basic astronomy.

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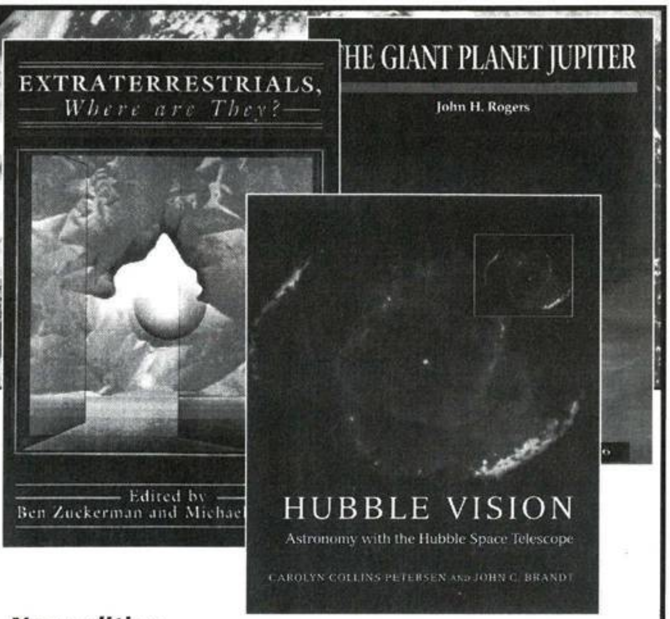
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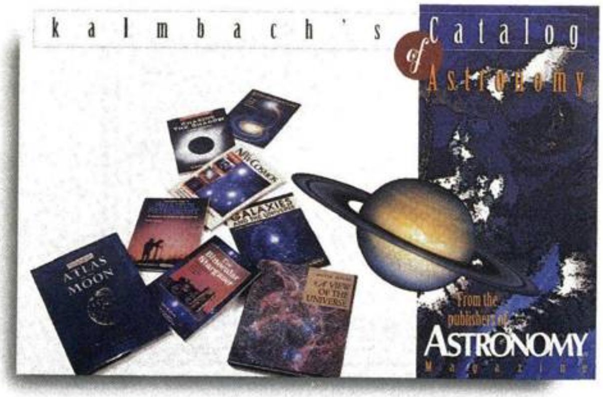
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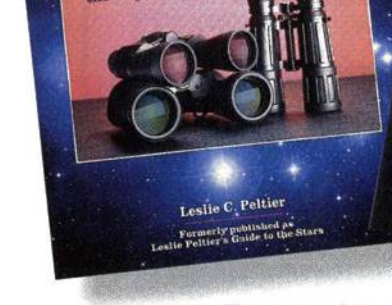
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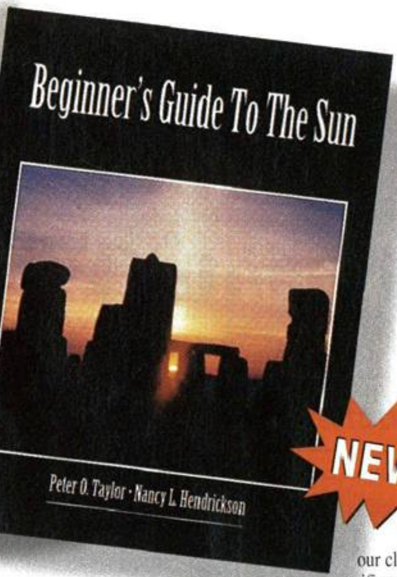
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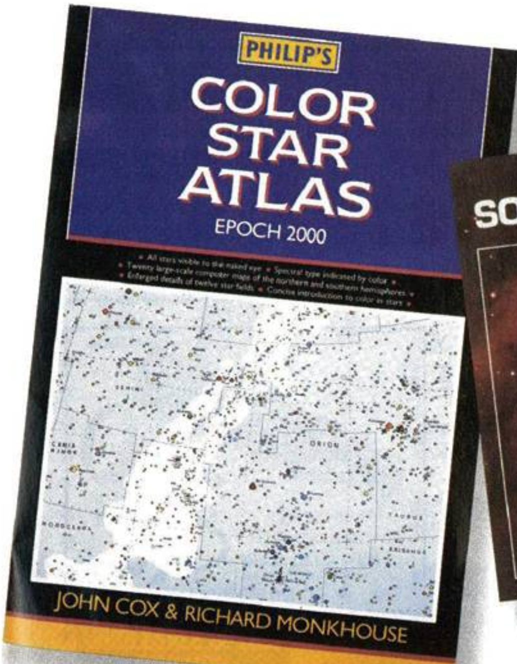
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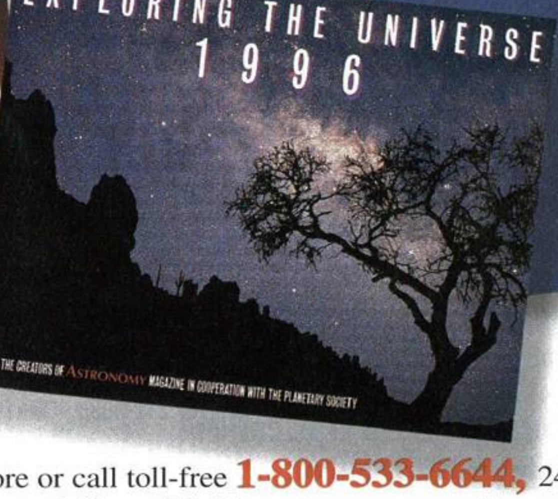
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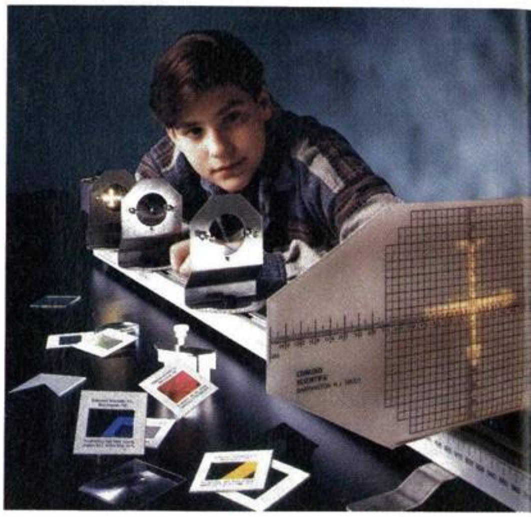

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Explore the optical theory behind eyepieces and telescopes with this laboratory optical bench. The bench includes an array of 50mm-diameter lenses and mirrors, filters, polarizers, diffraction gratings, an object slide, a long-lasting light source, and slotted and round aperture plates. A lab manual offers experiments in geometrical optics, basic optical instruments, and the polarization and diffraction of light. Lenses, filters, and mirrors slide into stands that ride on a one meter aluminum beam engraved with a 1,000mm scale. Optical combinations project images onto a 6" by 12" plastic screen that has an X-Y millimeter scale combined with a 5mm grid pattern. Ideal for college and high school optics labs or as a teaching aid for astronomy clubs.

Edmund Scientific Co., Dept. 15A1, C999 Edscorp Building, Barrington, NJ 08007-1380. (609) 573-6886; fax, (609) 573-6395. ES student Optical Bench, Model 39,510: $250.

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Porter Case, Inc. 122 Callander Drive, South Bend, IN 46614. (219) 291-5964; fax, (219) 291-1244. Porter Case II (item#1502-C): $249; foam liner kit (1502-F95): $39.95; divider system II (1502-DVK): $69.50.

Polaris Finderscope

Celestron introduces a 7x50 finder scope designed to aid scope owners in polar alignment. The straight-through finder features an etched illuminated reticle that shows the north celestial pole's position relative to Polaris. A plastic calculator dial lets you calibrate the reticle properly before aligning the main scope. Each finder includes mounting brackets and hardware that fit most Celestron telescopes.

Celestron International, 2835 Columbia Street, Torrance, CA 90503. (310) 328-9560; fax, (310) 212-5835.

New Products presents announcements issued by manufacturers. ASTRONOMY assumes no responsibility for the product information supplied. Prices are suggested retail. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com.

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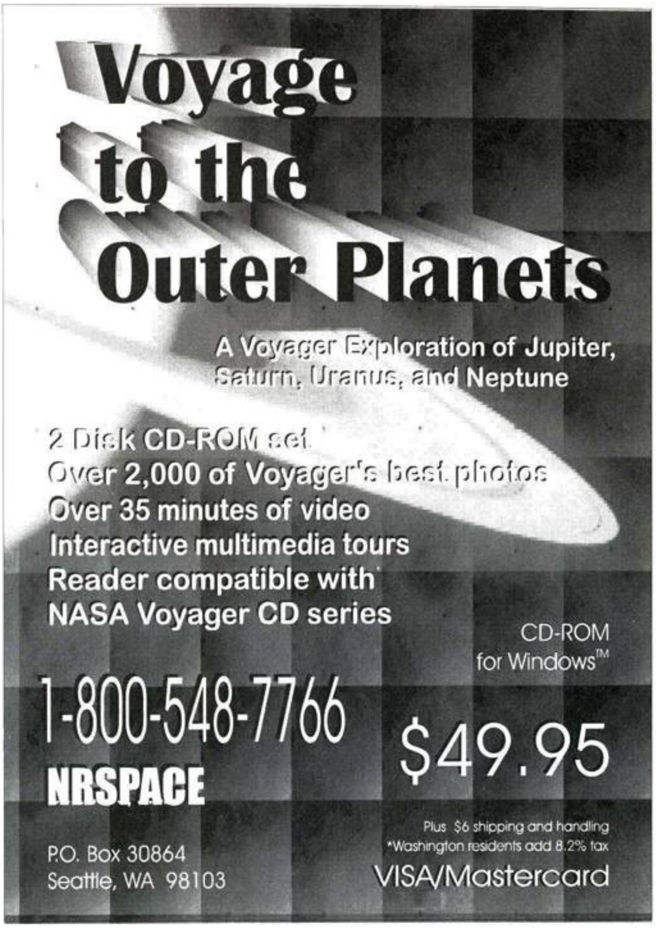

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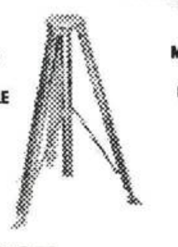

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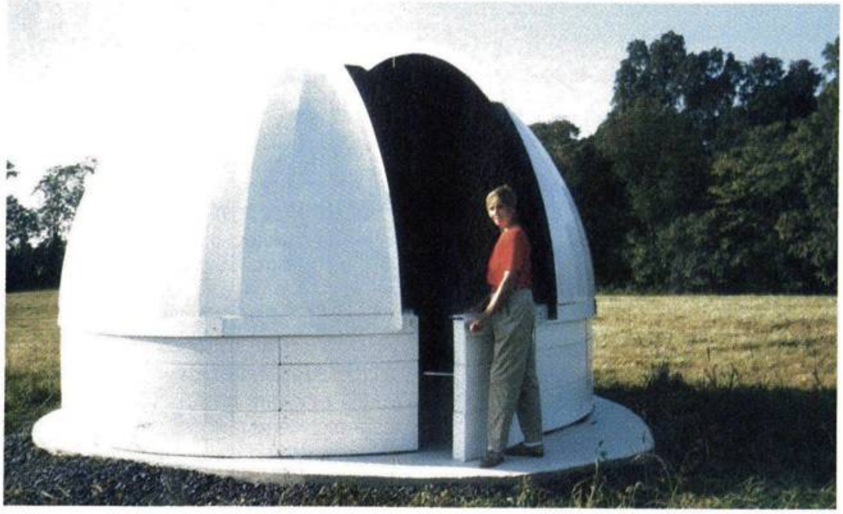

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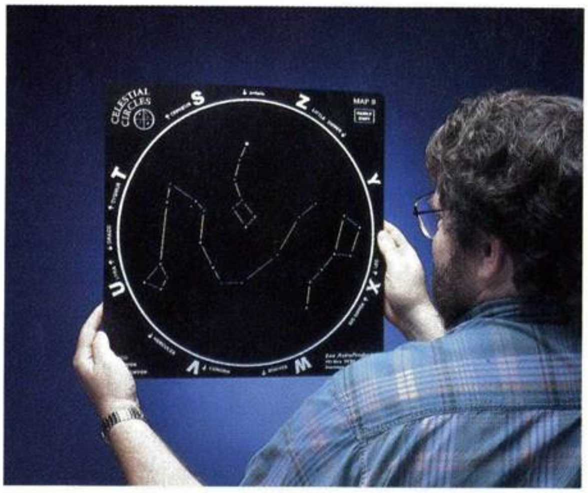

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Lee AstroProducts, P.O. Box 1056, Alva, FL 33920. (813) 339-9703. Celestial Circles Constellation Cards: $99. Quantity discounts are available.

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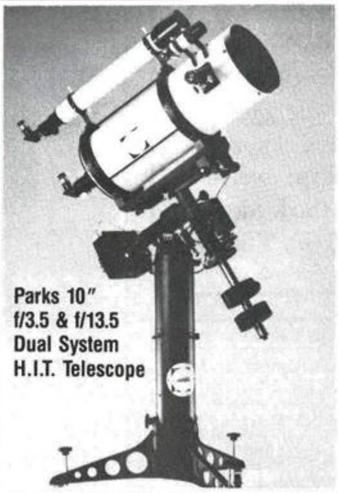

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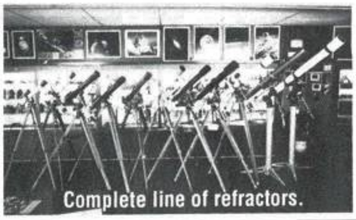

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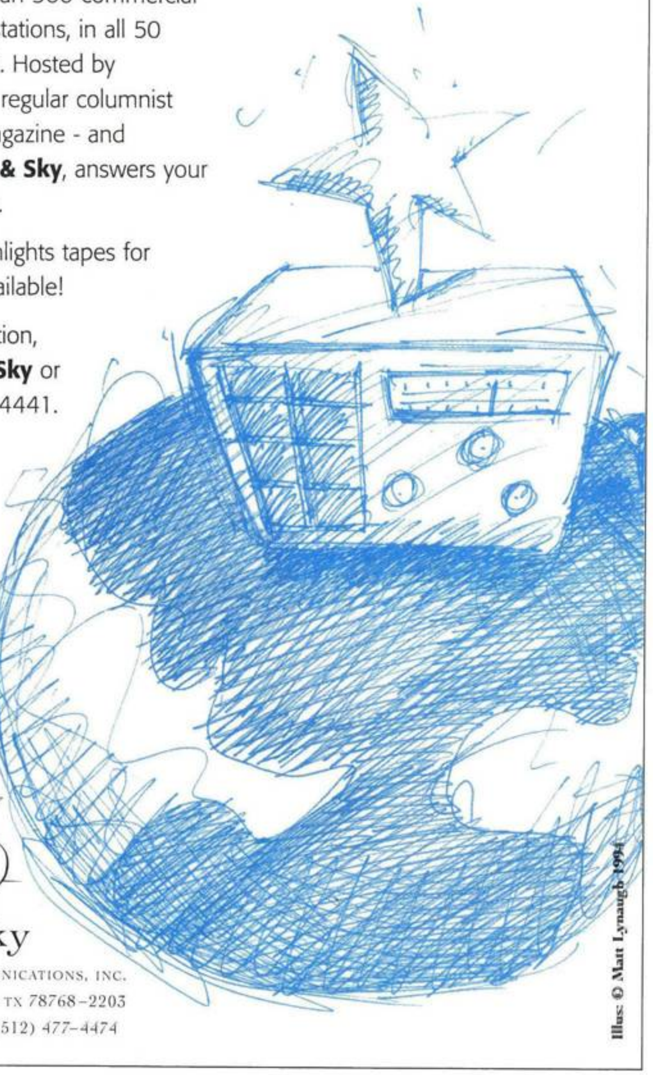

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Orion Telescope Center, P.O. Box 1158, Santa Cruz, CA 95061. (408) 464-0446; fax (408) 464-0466. EZ Finder Reflex Sight: $49.95

8-inch Hybrid Telescopes

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Telescope Engineering Company, Inc., 747 Sheridan Blvd. No. 6A, Lakewood, CO 80214. (303) 274-7944; fax, (303) 274-4115. MC200/11: $3,300; MC200/20: $3,500; Tube mounting rings: $240.

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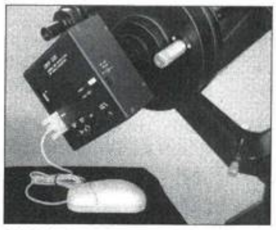

CWIP S shown with mouse.
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Are You Equipped?
Imagine producing more results than entire astronomy clubs, crowding walls with stunning images which are enhanced and printed exactly the way you want them. Next, imagine paying much less than you would for film, accessories and the telescope upgrades you'd need for such an ambitious program. You've just been thinking about a SIRIUS INSTRUMENTS CWIP CCD.

Saturn, before and after enhancement.
Pale cloud bands snap into view

CWIP CCD's combine the functions of all-digital ambient CCD Camera with Workstation for Image Processing, two key ingredients to successful images. Some CCD chips saturate at room temperature during readout, even with zero exposure time, making ambient operation impossible whereas the Sanyo LC9931 allows a minute per exposure at room temperature. While thermal charge accumulates more quickly than in cooled cameras, thermal noise accumulates only by the square root, resulting in extraordinary sensitivity with this impressive imaging chip. Precise dark frame calibration increases sensitivity 10-fold, much more than cooled 8-bit cameras, and multiple exposure summation takes sensitivity well beyond single exposure levels.

NGC5139 90mm f/4, 2x25 seconds with *SCD*

M82 otherwise invisible in badly light polluted skies. 90mm f/4 with *SCD*

Synthetic Clock Drive (SCD)
Use any optics! Most telescope drive systems are not precise enough for prolonged time exposures without expensive upgrades. CWIP CCD's offer two solutions: *Synthetic Clock Drive* allows you to turn your motors off and use as non-motorized scopes or lenses. By dialing in a shift rate, *SCD* electronically shifts the accumulating image at the drift rate of stars and other objects crossing the CCD chip. Or if your telescope has a moderately stable drive, shoot short time exposures. Either way, use flash alignment and summation to combine individual exposures for substantially more sensitivity. Image de-rotation software allows combining multiple exposures from altazimuth mounted scopes and lenses.

Model Comparison
CWIP-10's 10 bit A to D converter is 4X more sensitive than 8 bits. Pixel resolution is nearly triple that of comparably priced cameras. With full featured software, not a mini-version. The CWIP-10 is upgradable to any other model.
The CWIP-12's 12 bit A to D converter is approximately twice as sensitive as the CWIP-10 for the same exposure time.
CWIP Camera/Autoguider models offer the most interactive visual feedback to set up the autoguider and to diagnose and prevent autoguiding problems early. Autoguider capable telescope required.

Only the advanced CWIP-S can capture, store and process images without ever needing a computer. The video output displays control panels easily operated in the dark with a mouse (provided). Digital videotape data storage and retrieval uses a camcorder or VCR like a hard drive... for unlimited storage of redundant, reliable image data. Serial cable included.
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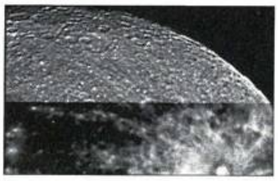

Moon image, split and processed two ways
(10" Newtonian with f/2 reducer and aperture)

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Specifications
CCD type: Sanyo LC9931 ambient frame transfer type. Resolution: 378h x 240v. CCD size: 1/3 inch diagonal. 12 bit sensitivity in 20 seconds exceeds: 9th magnitude (90mm scope),12th mag (8-inch),15th mag (16 inch).

M42 in Orion, 4 x 4 seconds, 8" f/10

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Model	Sensitivity (bits)		Complete outfit
CWIP-10	10	Camera	$449
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CWIP-12	12	Camera	$499
CWIP-12A	12	Camera/Autoguider	$549
CWIP-S	12	Stand-along Camera	$999

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MEETINGS & EVENTS

November 11
Ventura County Astronomical Society Swapmeet, Moorpark College Observatory, Moorpark, California. Contact Don Holland, (805) 526-4032 or the Starline (805) 529-7813.

November 16-18
4th Annual Star Party, Kissimmee State Park, Lake Wales, Florida. Sponsored by the Lake Kissimmee State Park. Contact George Aycrigg, 14248 Camp Mack Road, Lake Wales, FL 33853.

December 16
5th Annual Star-Be-Cue, near Heathcote, Victoria, Australia. Contact Perry Vlahos, 9A Hall Street, Cheltenham, Melbourne, Victoria 3192, Australia, 03-9583-5930.

January 27-February 2
Photonics West '96 Symposium, San Jose Convention Center, San Jose, California. Sponsored by the International Society for Optical Engineering. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010, (360) 676-3290, spie@spie.org.

February 15-18
The Orange Blossom Special, Hickory Hill Observing Complex, near Brooksville, Florida. Sponsored by the St. Petersburg Astronomy Club, Inc. Contact Dennis Farr, 8811 West Broad Street, Tampa, FL 33615, (813) 884-9111.

February 24
Wagman Winterfest, Wagman Observatory, near Russellton, Pennsylvania. Sponsored by the Amateur Astronomers Association of Pittsburgh. Contact the AAAP at Wagman Observatory, (412) 224-2510.

February 25-29
Smart Structures and Materials Symposium, Catamaran Resort Hotel, San Diego, California. Sponsored by the International Society for Optical Engineering. Contact SPIE, P.O. Box 10, Bellingham, WA 98227-0010, (360) 676-3290, spie@spie.org. ☐

Readers, when writing to organizations listed, include a self-addressed, stamped envelope with your request for information. Clubs, please submit announcements four months in advance to Tracy Staedter, Meetings & Events, ASTRONOMY, 21027 Crossroads Circle, Waukesha, WI 53187, or tstaedter@astronomy.com.

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RESOURCES & PHOTOFACTS

The Mars That Never Was (page 36)

"Chesley Bonestell's Astronomical Visions," *Scientific American*, May 1994. Retrospect on Bonestell's hypothetical — and sometimes foresightful — views of the solar system.

Worlds Beyond: The Art of Chesley Bonestell, by Frederick C. Durant III and Ron Miller (Donning, 1983). Presents various views of the solar system by the famous space artist.

The Exploration of Mars by Willy Ley and Wernher von Braun, (1956 and out of print). Presents the "latest" theories about Mars, its surface conditions and features, and a manned Mars mission. Look for it in used book stores.

Mars: The Story of the Red Planet, by Peter Cattermole (Chapman and Hall, 1992). The geology and meteorology of Mars. Contains many never-before-seen Viking images.

Epsilon Eridani: The Once & Future Sun (page 46)

Is Anyone Out There? The Scientific Search for Extraterrestrial Intelligence, by Frank Drake and Dava Sobel (Delacorte Press, 1992). Chapter Two contains Drake's first-person account of Project Ozma, his search for artificial radio signals from Epsilon Eridani and Tau Ceti.

The Secrets of Orion's Great Nebula (page 78)

Burnham's Celestial Handbook, by Robert Burnham, Jr. (Dover, 1978). A massive, three-volume tome on deep-sky objects arranged by constellations that features a lengthy section on the Orion Nebula.

When Galaxies Strut Their Stuff (page 88)

Stars and Galaxies: ASTRONOMY'S Guide to Exploring the Cosmos, edited by David J. Eicher (Kalmbach Books, 1992). Contains many articles describing galaxy observing.

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pp. 78-79: Bill and Sally Fletcher, 16-inch f/4.5 reflector, hypersensitized Fuji Super HG 400 film; **p 80, top:** John C. Mirtle, 6-inch f/4.5 reflector, Ektachrome 400 film, 40-minute exposure using a Deep-Sky filter; **bottom left:** Jason Ware, 6-inch refractor, hypersensitized Fuji Super HG 400 film, composite of four 60-minute exposures and one 12-minute exposure; **bottom right:** Mace Hooley; **p. 82:** Edwin Faughn, 20-inch reflector, composite drawing using several magnifications; **p. 83:** Jim Baumgardt, 10-inch f/20 Cassegrain, hypersensitized Fuji 400 film, 10-minute exposure; **p. 88, top:** Jerry Armstrong and Tim Puckett, 16-inch f/6 reflector, ST-6 CCD camera; **bottom:** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; **p. 89, top:** Jack Newton, 25-inch f/5 reflector, Pictor 1616 CCD camera; **bottom left:** Greg Terrance, 16-inch f/5 reflector, ST-6 CCD camera; **bottom right:** Jack Newton, 25-inch f/5 reflector, Pictor 1616 CCD camera; **p. 90, top:** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; **bottom:** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; **p. 91, top:** Stéphane Dumont, 9-inch SCT at f/12, ST-6 CCD camera; **bottom:** Jack Newton, 25-inch f/5 reflector, Pictor 1616 CCD camera; **p. 92, top:** Nik Syzmanek and Ian King, 4-inch refractor at f/7, ST-6 CCD camera; **bottom:** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; **p. 93, top:** Steven Lee, 8-inch reflector, Cookbook 245 CCD camera; **bottom:** Jack Newton, 25-inch f/5 reflector, ST-6 CCD camera; **p. 123, top:** Randall Wehler, 28mm lens at f/2.8, Scotch-Chrome 400 film, 4-minute exposure; **bottom left:** Phil Dombrowski, 11-inch SCT at f/6, 103a-F film, 8-minute exposure taken in June 1985; **bottom right:** Phil Dombrowski, 11-inch SCT at f/6, Kodacolor 1000 film, taken in July 1995; **p. 124, top:** Lee C. Coombs, 6-inch apochromatic refractor at f/36, 200 ISO film, 1-second exposure taken June 8, 1995; **center:** Terry Holmes, 50mm lens at f/2.8, Kodachrome 64 film, 20-second exposure on July 5/6, 1995; **bottom:** Bob and Janice Fera, 11-inch f/10 SCT, hypersensitized Fuji Super G 800 film, composite of two 75-minute exposures; **p. 125, top:** Michael Stecker, 5-inch apochromatic refractor at f/6, composite of two 50-minute exposures **bottom:** Chuck Vaughn, 12.5-inch f/9 Ritchey-Chretien, hypersensitized Tech Pan film, 90-minute exposure; **p. 126, top left:** Luke Dodd, 300mm lens at f/4, hypersensitized Fujicolor 400 film, 30-minute exposure; **top right:** Greg Terrence, 16-inch f/5 reflector, Lynxx CCD camera, 1 1/4-second exposure taken August 15, 1995; **bottom:** Kim Zussman, 14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 204-minute exposure; **p. 127, top:** George Greaney, 6-inch f/7 refractor, hypersensitized Fuji Super HG 400 film, composite of two 60-minute exposures; **bottom:** Jack Newton, 25-inch f/5 reflector, Pictor 1616 CCD camera; **p. 128:** Eric DeBolt, 16mm lens at f/4.5, Fuji Velvia film, 9.5-hour exposure. ☐

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Pro-Optic 500mm f/5.6 lens	**234.95**
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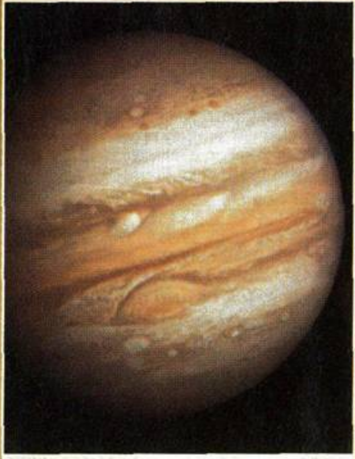

NASA/JPL

GALILEO ARRIVES AT JUPITER Its six-year journey finally over, the Galileo spacecraft prepares to revolutionize our knowledge of the giant planet and its family of satellites.

CATCH THAT COMET ON FILM
With the bright comet Hale-Bopp set to make an impressive appearance, now's the time to hone your technique for capturing this cosmic interloper.

THE PLANETS NO ONE EXPECTED
Incredible as it may sound, planets do exist in the hostile environs of pulsars. How did they get there, and what might these exotic places be like?

POWER TO GO
Here's an easy weekend project that can bring power to a telescope and two electrical accessories while you're observing under a dark, rural sky.

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Under the Shadow of a Galaxy

"Can a galaxy really cast a shadow?" asks Brenda Culbertson, a backyard astronomer from Harveyville, Kansas. She is serious in her query, something that may seem queer in light of the widespread impression of galaxies as extraordinarily distant, dim splotches of light as seen in big telescopes.

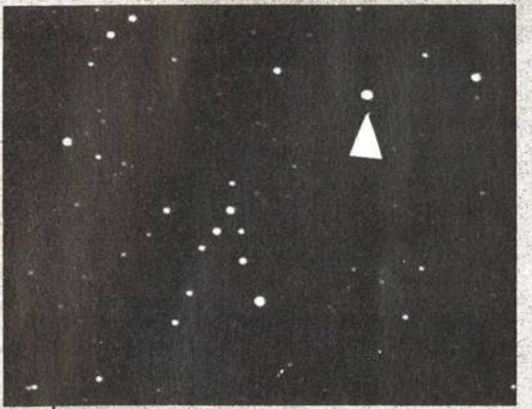
But as Culbertson reminds us, there are places left on Earth where 200 people can get together and see shadows cast by the Milky Way arching overhead. Such a place was the Merritt Reservoir State Park in Nebraska's Sand Hills, where the Nebraska Star Party took place on July 25-30, 1995. The event was cohosted by the Prairie Astronomy Club of Lincoln, Nebraska, and the Omaha Astronomical Society.

Held at New Moon at an elevation of 3,100 feet, the star party offered Plains States astronomers the chance to witness dark skies and deep-sky objects. "The night sky was ablaze with wonders most amateurs can only dream about," Culbertson says. "The Milky Way illuminated the night sky with such brilliance that people could discern the colors of their clothing and faint shadows cast on the ground, and could read their star charts without the aid of a flashlight."

The sizes of telescopes on the observing field ranged from 5 inches to 30 inches. On Friday the 28th the focus on observing shifted gears and the group moved to Valentine, Nebraska, 34 miles fom the observing site, for a series of talks and a

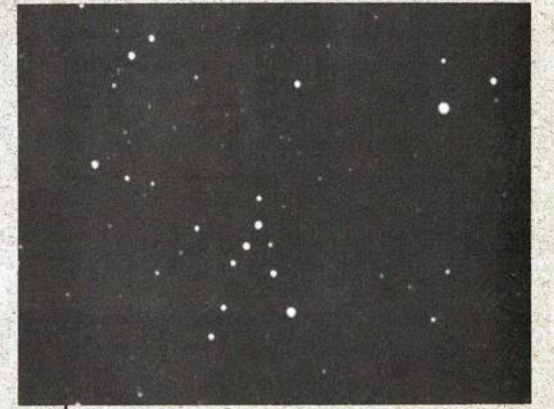
Milky Way Over the Nebraska Star Party

by Randall Wehler (28mm lens at f/2.8, ScotchChrome 400 film, 4-minute exposure)



Barnard's Star in 1985

by Phil Dombrowski (11-inch SCT at f/6, 103a-F film, 8-minute exposure taken in June 1985)



Barnard's Star in 1995

by Phil Dombrowski (11-inch SCT at f/6, Kodacolor 1000 film, taken in July 1995) banquet. The main speaker was Barbara Wilson of Houston, Texas, an enthusiastic deep-sky observer, who spoke on observing challenging globular star clusters.

Randall Wehler of Willmar, Minnesota, attended the star party, his first outside his home state save for Astrofest in Illinois. "Armed with 11x80 binoculars, I swept the Milky Way and found a load of deep-sky delights," says Wehler. "So many stars were visible in the field surrounding Gamma Cygni that I had trouble making out the open cluster M29."

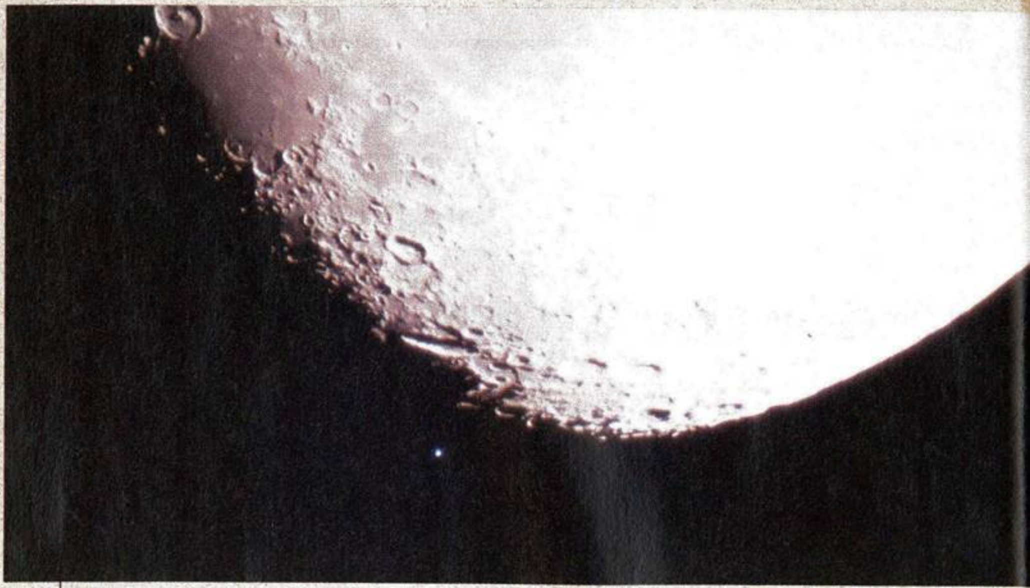
Next year's Nebraska Star Party will occur from August 10-17, to coincide with the Perseid meteor shower under dark skies.

A Decade of Barnard's Star. Phil Dombrowski of Glastonbury, Connecticut, is an observer with a dogged persistence. In 1985 he photographed Barnard's Star, the 10th-magnitude star in Ophiuchus with the highest proper motion of any star in the sky.

Because it is close to us and moving through the Galaxy at a high speed, Barnard's Star appears to move relative to the background stars more than any other star — some 10" per year.

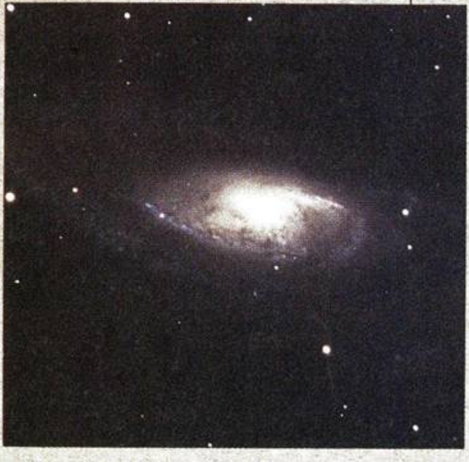
Last July, Dombrowski returned to his subject of the mid-1980s and photographed the star again with essentially the same photo setup. His pair of images show the star's motion over a decade, during which it shifted by 103" relative to the stars surrounding it. Barnard's Star waits for more long-term astrophotographers. Anyone else with as inventive a way to spend the next decade? ☐

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Please label each photo with name, address, and social security number. You may send written reports via the Internet to: rreports@astronomy.com



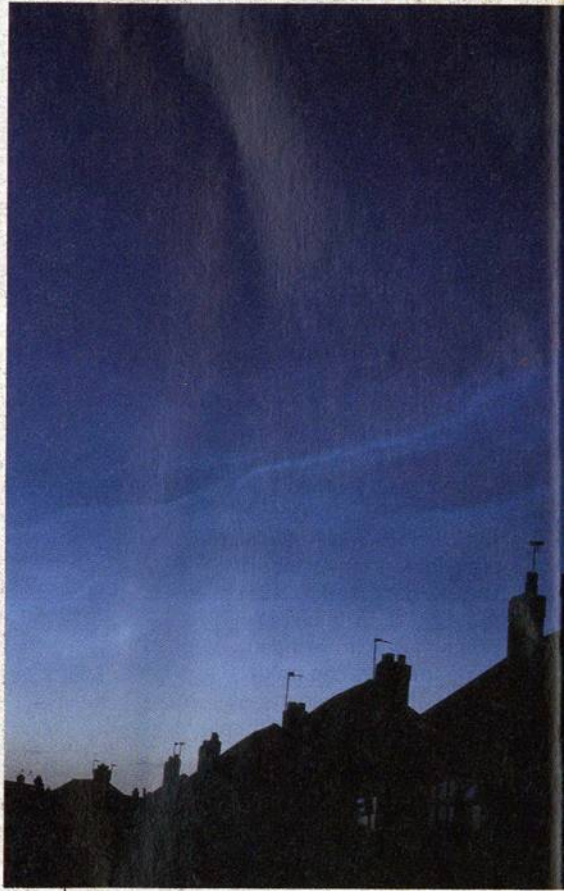
The Moon Passes Spica

by Lee C. Coombs
(6-inch apochromatic refractor at f/36, 200 ISO film, 1-second exposure on June 8/9, 1995)



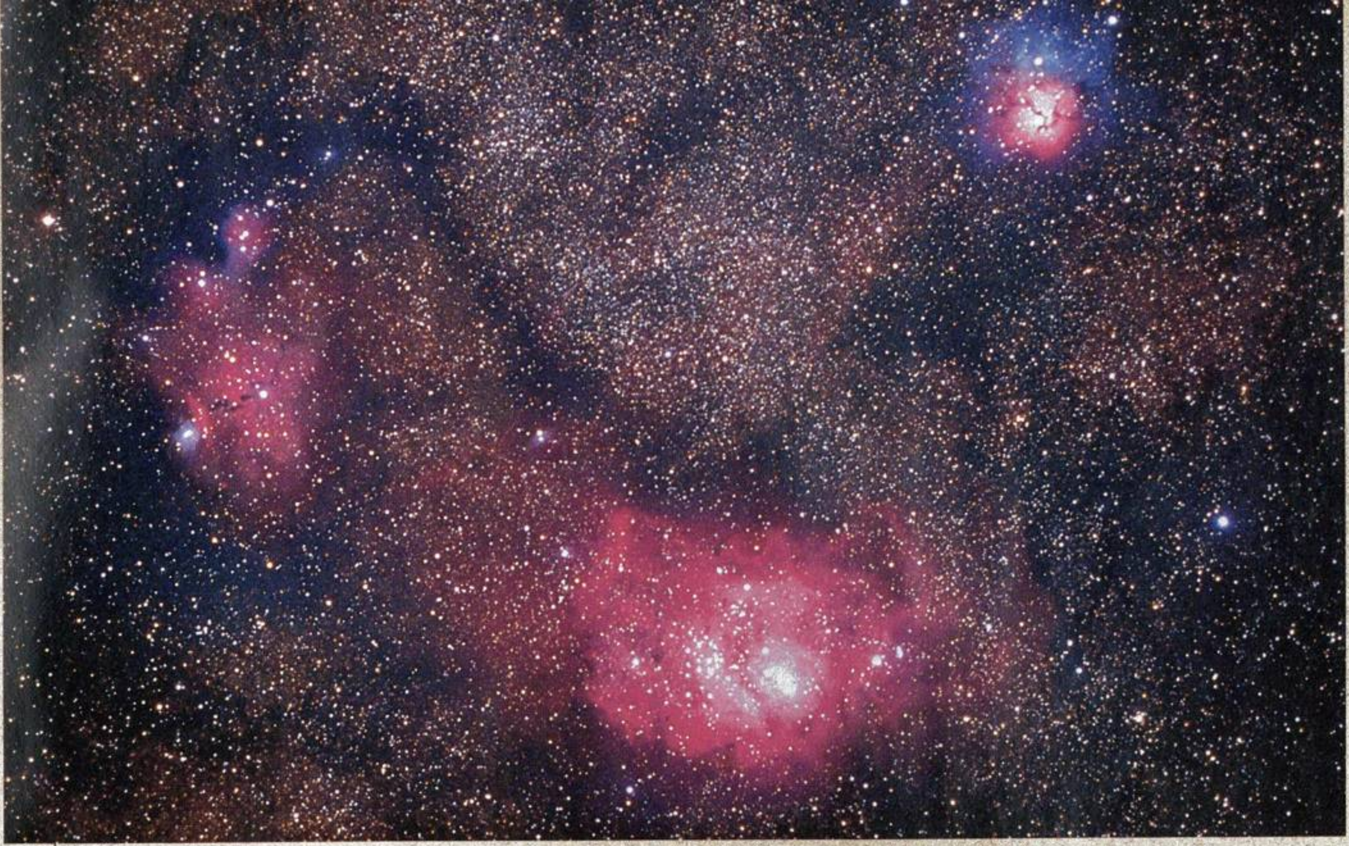
Galaxy M106 in Canes Venatici

by Bob and Janice Fera
(11-inch f/10 SCT, hypersensitized Fuji Super G 800 film, composite of two 75-minute exposures)



Noctilucent Clouds Over England

by Terry Holmes
(50mm lens at f/2.8, Kodachrome 64 film, 20-second exposure on July 5/6, 1995)

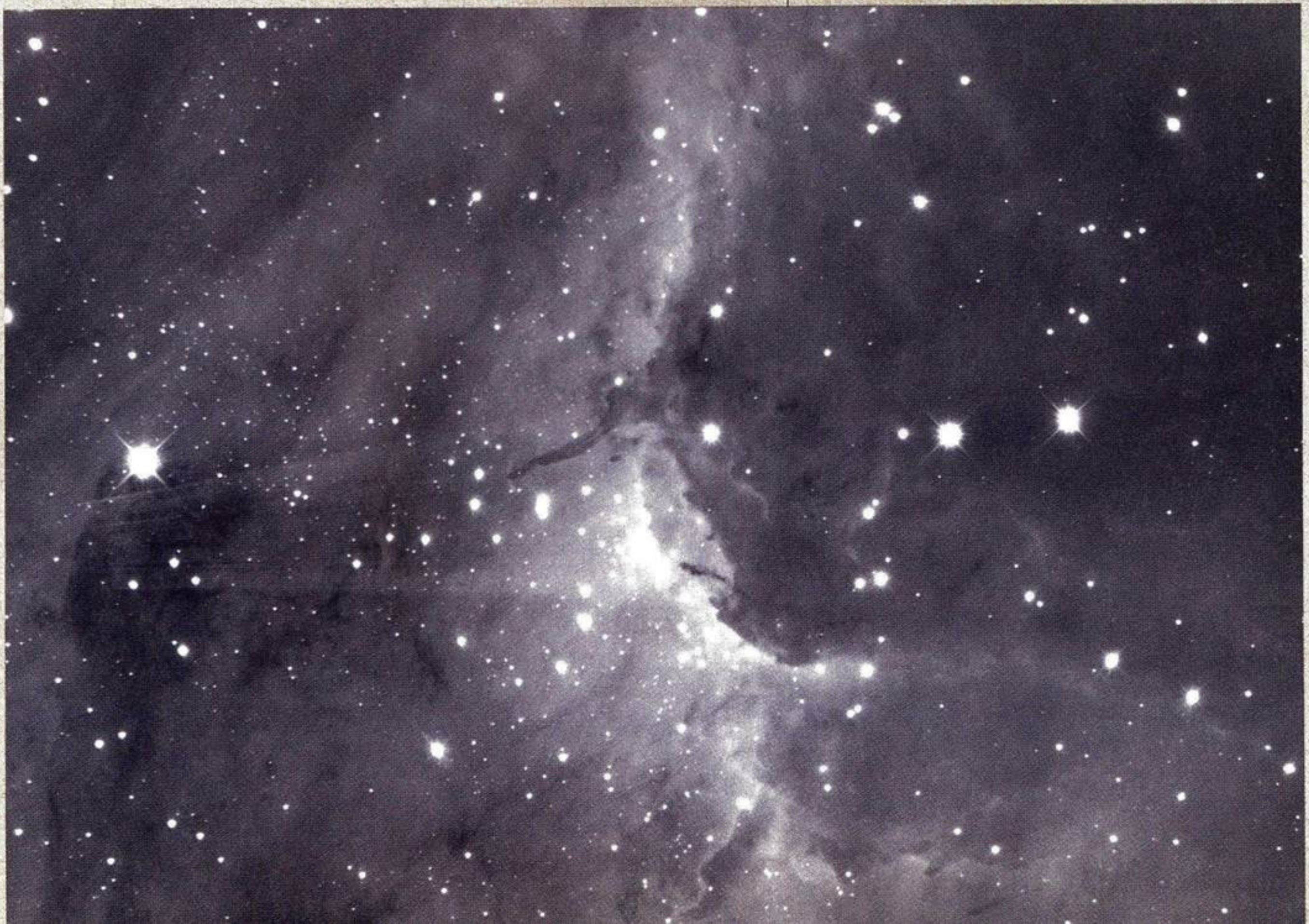


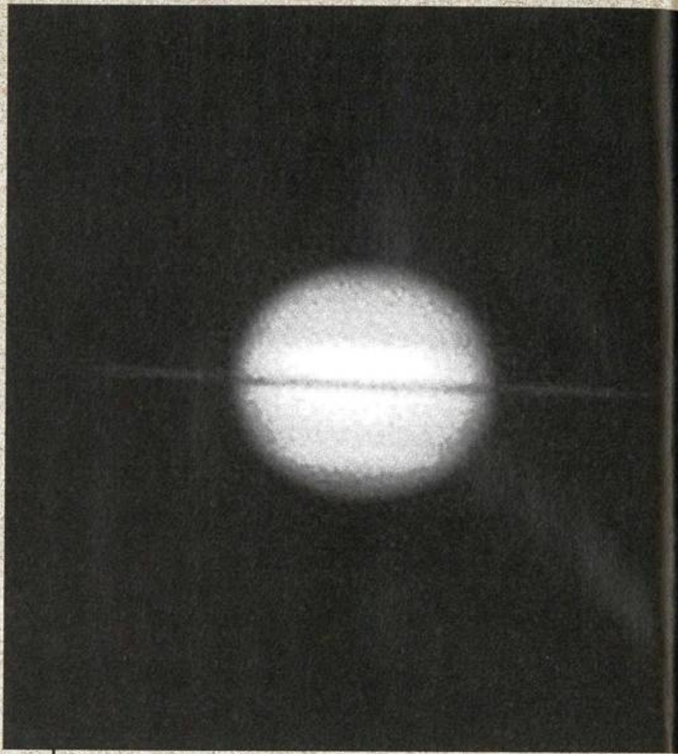
The Lagoon and Trifid Nebula

by Michael Stecker
(5-inch apochromatic refractor at f/6,
composite of two 50-minute exposures)

The Pelican Nebula in Cygnus

by Chuck Vaughn
(12.5-inch f/9 Ritchey-Chretien, hypersensitized
Tech Pan film, 90-minute exposure)





Ringless Saturn

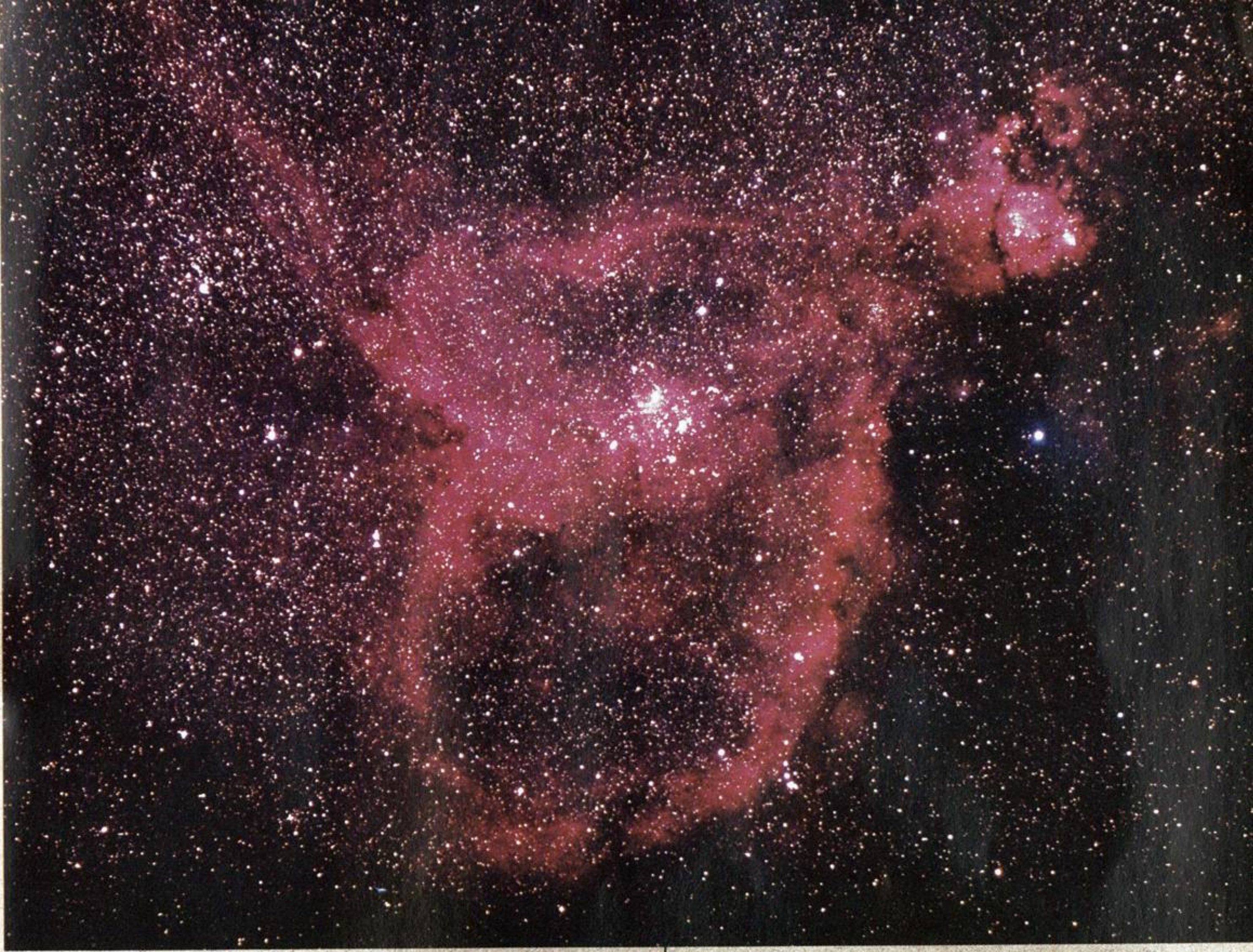
by Greg Terrence
(16-inch f/5 reflector, Lynxx CCD camera, 1¼-second exposure taken August 15, 1995)

The Southern Cross

by Luke Dodd
(300mm lens at f/4, hypersensitized Fujicolor 400 film, 30-minute exposure)

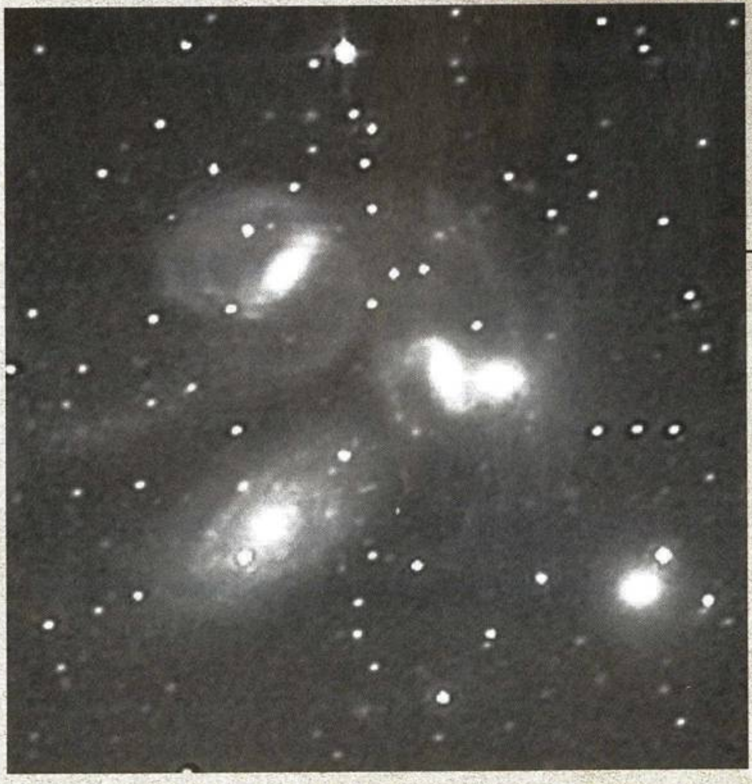
The Hercules Galaxy Cluster (Abell 2151)

by Kim Zussman
(14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 204-minute exposure)



Emission Nebula IC 1805 in Cassiopeia

by George Greaney
(6-inch f/7 refractor, hypersensitized Fuji Super HG 400 film, composite of two 60-minute exposures)



Galaxy Group Stephan's Quintet in Pegasus

by Jack Newton
(25-inch f/5 reflector, Pictor 1616 CCD camera)

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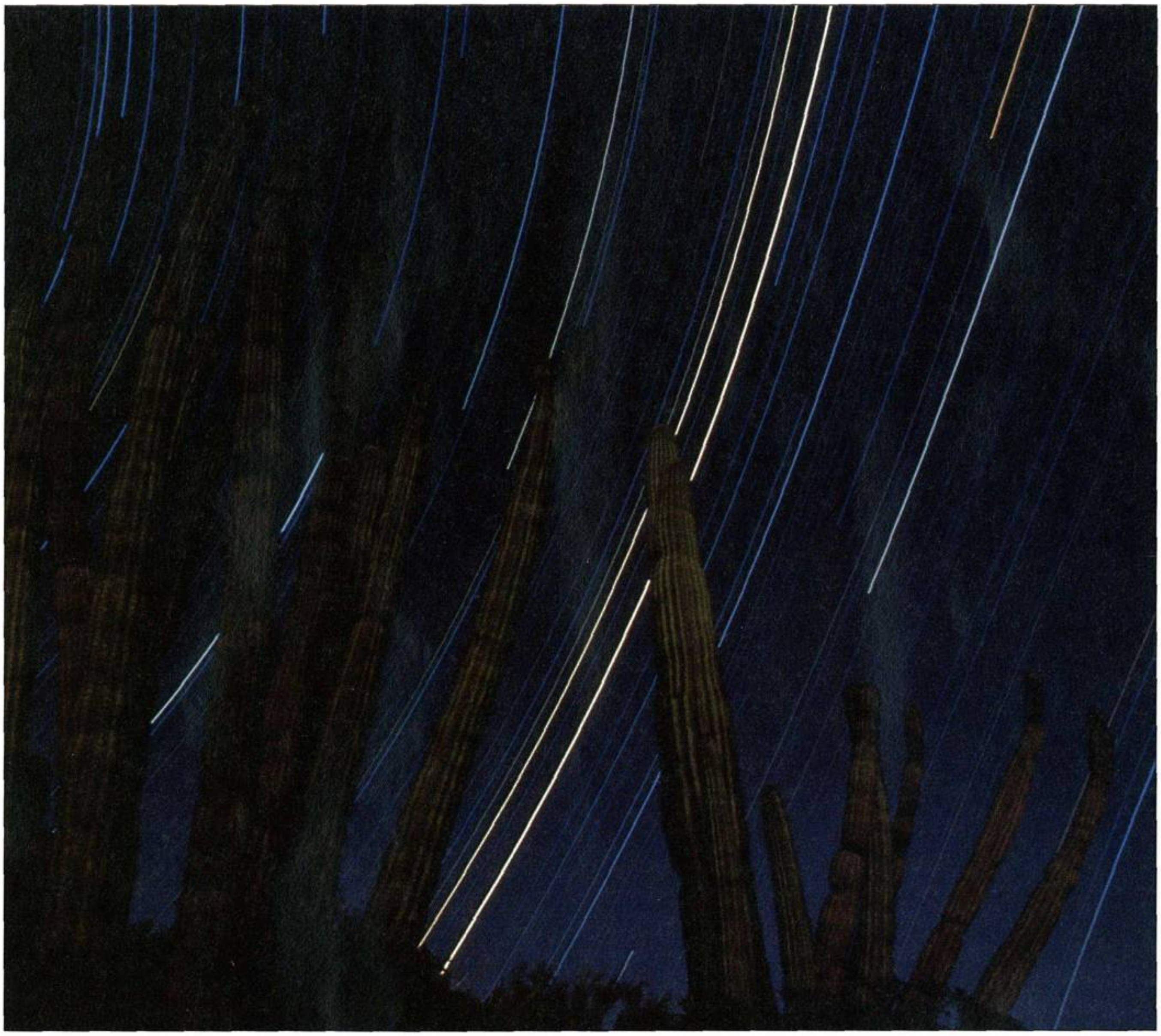

Star Trails Over the Sonoran Desert, Arizona

by Eric DeBolt
(16mm lens at f/4.5, Fuji Velvia film, 9.5-hour exposure)

A group of organ pipe cacti stands in the foreground and is illuminated by starlight in this extraordinarily long exposure taken throughout a dark night early last summer.

"I'm a Seattle-based freelance photographer," says DeBolt, "and for several years have been working on perfecting this technique of shooting long star trails. I've been an ASTRONOMY reader since my high school days."

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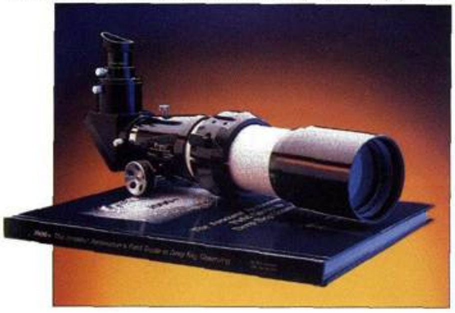

No picture or description prepared me for the beauty of the design or the excellence of the workmanship. J.T. - RI

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Well done! Saw the Owl and M108 in same field. T.J. - KS

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Compact, easy to carry & solid case. Delivers one of the best, false-colour-free images I've ever seen in this size & aperture! Thank you. B.D. - Germany

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I am greatly satisfied with the quality of craftsmanship that was put into this fine instrument. M.H. - PA

Fantastic! Sharp views of planets, moon and star fields...excellent high power results!! J.C. NJ

It's the only scope I recommend to friends. B.H. - KS

Superb optics! Sharpest images of any scope I've ever owned. Pinpoint star images. R.M. MD

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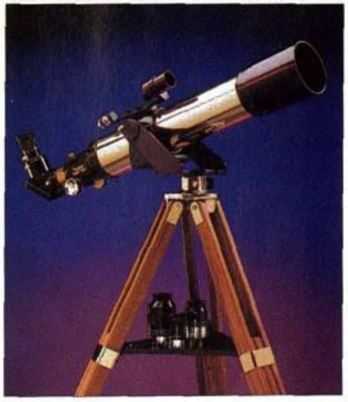

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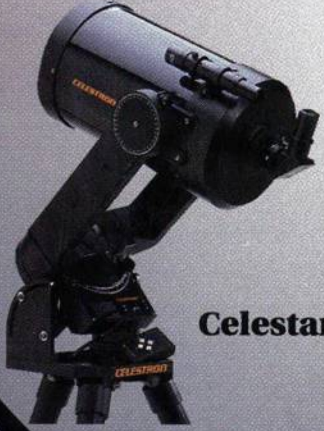

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